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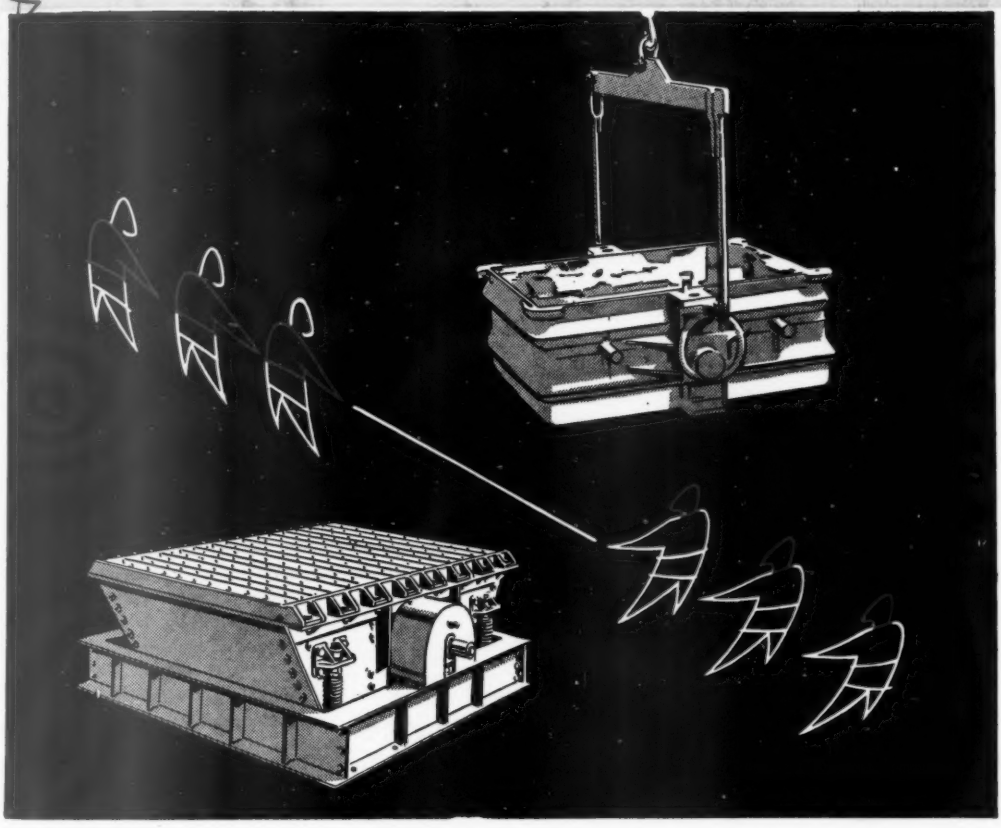

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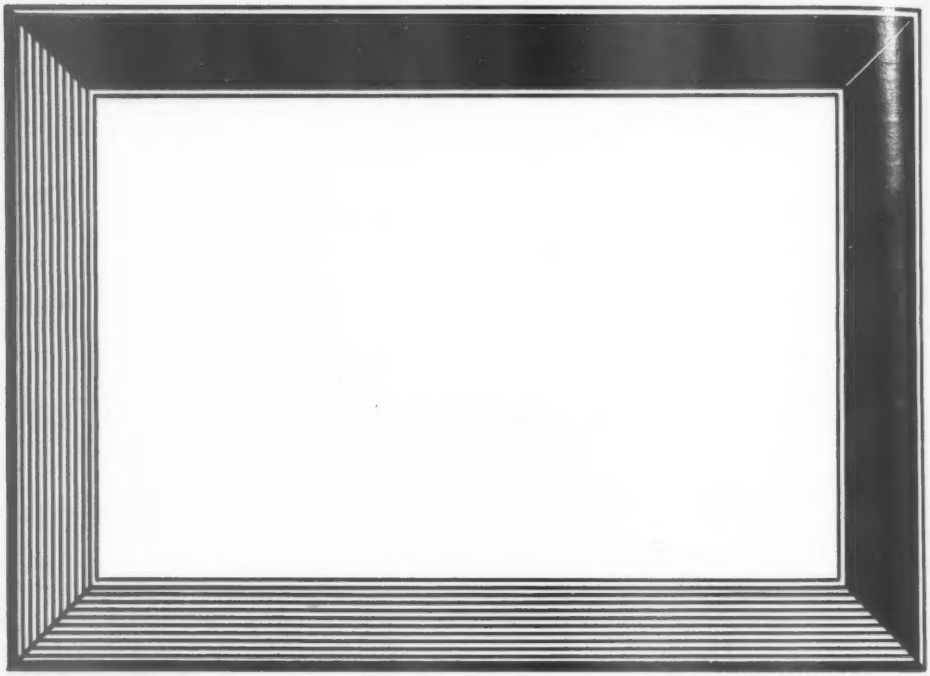

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New Safety Standard

One of the shortest and most important British Standard specifications (BS.2929 : 1957) has just been published. It covers the subject of safety colours for use in industry and its object is to ensure uniformity in the workshops of the country for visual notification of hazards or directions for safety. Put shortly, red means either stop, the location of fire-fighting equipment or the storage of explosives. Orange yellow is used to imply a warning of danger, whilst green symbolizes the location of safety equipment or the best escape routes in case of emergency. One result of this last direction is that on first-aid boxes the well-established red cross should be changed to a green one. This, in any repainting scheme, we should leave to the last as it makes the least contribution to safety. The green cross is usually associated with animal welfare.

Because some people are colour blind and in some cases we have encountered are unable to distinguish between red and green, the specification lays it down that a red and white chequered pattern should, where necessary, be used. What we have termed "tiger" stripes, that is orange and black, is specified for indicating danger spots. We deem this clause to be the most important of all and it should be applied to such movable points as the head of the impeller type of sand rammer and the projecting components of fork-lift trucks. We would suggest that where sharp corners exist in tables, these too could be usefully so treated. Pendulum conveyors also need "tiger" stripes.

Colour systems for service pipelines have already been standardized and there is no need to change them, but where they leave walls and become suspended and thereby constitute a hazard, then there is a case for colouring an appropriate length with "tiger" stripes. The factor to bear in mind is not to overdo the painting of warnings, as the existence of too many will defeat their purpose. They should be restricted to projecting mobile parts and unavoidable constructional hazards. In effect, they need not cater for those regularly working in the shop, but for new employees and casual personnel. The greatest value of this new specification will be in widespread application, for it is by this means that everybody in industry will become familiar with its import. Founders generally are so conscious of accident prevention that we are reasonably sure that they will be among the first to adopt the new standard. With the advent of the European Free Trade Area, it is of no little interest to note that the same symbols are to be found throughout the territory to be covered. After a visit to Scandinavia, it was reported that these warning signs were used there, and it is pleasing to learn that our approbation of the system resulted in some emulation by the home foundry industry. The new standard will no doubt accelerate this action.

G

Production Exhibition and Conference

Lord Mills, K.B.E., Minister of Power, has consented to open the third Production Exhibition and Conference, which will be held in the Grand Hall, Olympia, London, from May 12 to 21, 1958. The president of the exhibition and conference will be the Earl of Halsbury, F.R.I.C., F.INST.P., who is president of the Institution of Production Engineers, sponsors of the project. The theme is to be "Production Fights Inflation," and its purpose is to place before the public examples of some of the best production technology employed in this country, and to show how the work of scientists, designers and development engineers is passed on to the consumer as a result of the application of modern production-technology. Many of the stands will be manned by technologists and scientists who can explain their work to visitors.

The technical papers to be given will also be related to this general theme, and will deal with such subjects as power for production; the selling of products abroad; economic background to national production problems; designing of electronically controlled production machinery; operational research and cybernetics; and, most important of all, human aspects of manufacture.

1959 Foundry Exhibition Site Decided

Bingley Hall, Birmingham, is to be the site of the UK national foundry exhibition to be held in May, 1959. The exhibition will show something of the part which founders play in every modern enterprise and demonstrate the tremendous developments in foundry processes and equipment which have taken place in recent years. Thus joint participation of founders and manufacturers of equipment and supplies is envisaged. Details as to the scope of the exhibition and availability of stand space will be published shortly.

Foundry Equipment & Supplies Association

The second annual dinner of the Foundry Trades Equipment & Supplies Association is to be held at the Savoy Hotel on February 19, 1958. It is interesting to note that the first one was held at the now defunct Engineers' Club in 1926. During this lapse of 31 years the "Equipment" association has grown very considerably, and already the forthcoming dinner is an assured success. Over 100 applications for tickets have been received. Details of the function are available from the FTE & SA secretaries, Peat Marwick, Mitchell & Company, 94-98, Petty France, London, S.W.1.

At a meeting of the Council of the Association held last week, the following new members were admitted: Woodstock (London), Limited; Balbardie, Limited; and Hepburn Conveyor Company, Limited.

Luncheon

H. C. HOPPER (KINGSTON) LIMITED

The directors of H. C. Hopper (Kingston) Limited, Mr. H. C. Hopper and Mr. R. Scott, entertained customers, suppliers and friends to luncheon at the Mitre Hotel, Hampton Court, last Thursday. Amongst the guests were Mr. V. C. Faulkner, Mr. R. Buxton, Mr. Darby and Mr. Hartley from Birmingham.

A MEETING of members in the Yorkshire area of the Association of Bronze and Brass Founders will be held in the Hotel Metropole, King Street, Leeds 1, on Friday, December 20, commencing at 12.15 p.m. First there will be a report and discussion of the activities of the Association, which will continue until luncheon at 1 p.m. The latter will be followed by a discussion on the recent "Survey of Furnaces for Melting Copper-alloys, with Cost Data compiled under Production Conditions in Sand Foundries."

UK Steelfounders Honoured

Mr. L. W. Sanders, chief metallurgist, Lake & Elliot, Limited, and Mr. T. A. Cosh, head of the steelmaking section of the British Steel Castings Research Association, have just returned from America. They went as part of the scheme for the exchange of lecturers between the BSCRA and the Steel Founders' Society of America (announced recently) and while in America presented papers at a meeting on November 11, on the application of the graphite-rod resistor furnace and immersion pyrometry for molten steel, respectively. Afterwards they each received an "Award of Honor" from their American hosts and the ceremony accompanying this presentation is shown in the illustration below.

Presentation of SFSA "Award of Honor" to British lecturers. From left to right: Mr I. M. Emery, president Massillon Steel Casting Company, Mr. L. W. Sanders; Mr. T. A. Cosh; Mr. H. F. Park, jun., SFSA president and vice-president General Steel Castings Corporation; and C. W. Briggs, technical and research director, Steel Founders' Society of America.

Recent Developments in the Manufacture of Castings*

By J. L. Rice,† B.Met., R. W. Ruddle, M.A., and P. A. Russell, B.Sc.

[ABRIDGED]

(*Continued from page 672*)

This article which commenced last week with a review of developments in established foundry processes over the last 5 to 10 years, and went on to survey the emergence of shell-moulding practice, continues this week with an account of the nature and significance of the CO_2 Process, precision-investment casting, the Shaw process and other new or revived techniques. This middle section of the Paper concludes with a review of alloy development with regard to grey, malleable irons and spheroidal-graphite irons, copper and aluminium alloys.

Carbon-dioxide Process

In shell moulding, the mould is not separated from the pattern until it is hard, which explains in part the good dimensional accuracy obtainable. Similarly, with the CO_2 process, in which a sodium-silicate-base binder is mixed with silica sand and the rammed mass hardened by blowing carbon dioxide gas through it. Only then is the pattern normally removed. To a large extent the CO_2 process is complementary to, rather than competitive with shell moulding, although where small cores are concerned there is some overlapping in their field of usefulness. At the present time, the standards of accuracy and surface finish are not so high as for shell moulding, but this gap is likely to narrow in the future as fine sands of the shell-moulding type come into use. Such an accuracy, however, presupposes the supply of pattern equipment of a similar standard—and of similar price—to that required for shell moulding and this implies relatively large production orders, although the CO_2 process is of much wider application than would appear from this initial statement.

One of the main fields of usefulness is undoubtedly in jobbing foundrywork where quantities are small and where the reduced demand on the skill of the moulder which the process makes possible would be of most value. A word of warning is needed here. Since the mould or core is hard and unyielding when gassed, some modification may be needed in pattern equipment, usually along lines which enable the pattern or corebox to be dismantled in sections. To get the maximum benefit from the process, the founder must not be presented with pattern equipment in the method of construction of which he has not been consulted. The speed with which even large moulds and cores can be produced makes the process particularly suitable for "rush" jobs such as breakdown replacements and the process undoubtedly represents the most important tool which has been put into the hands of the jobbing foundry in recent years.

All the common ferrous and non-ferrous alloys can be cast by the process. At the present time, its principal applications are with cast-iron, steel and for sand cores used in aluminium gravity-die-castings. Examples of castings made by the process are shown in Fig. 6.

Precision Investment Casting

The "lost wax" process is of great antiquity and was widely used for statuary bronze at the time of the Renaissance. It entered a new field during the last war when it was adapted, and renamed precision investment casting, for the manufacture of small castings in heat-resisting alloys which, by exhibiting good mechanical properties at high temperatures, met the needs of the gas-turbine. These alloys are extremely hard and it is therefore desirable to keep machining to a minimum.

Briefly, wax patterns are made by injecting wax into metal dies and are then assembled around a wax running-system. This assembly is coated with a fine refractory and then invested with a slurry composed of refractory and an ethyl-silicate binder. The whole is dried at a temperature below the melting point of the wax. The wax pattern is then melted out and the refractory mould fired at a high temperature before casting.

Later developments described by Turnbull (1955) have included the elimination of the slurry investment by substituting a series of dip coatings; and the use of trichlorethylene to dissolve out the wax. Another variant is the "Mercast" process, in which frozen mercury is substituted for wax as a pattern material (Kramer, 1955).

Precison investment casting is essentially a specialized process and it seems highly unlikely ever to be used for large tonnages. But dimensional accuracy is high, tolerances of ± 0.003 in. per in. or less being often possible, and since the pattern is melted or dissolved to ensure its removal from the mould cavity, there is no joint line, with its attendant inaccuracies.

*Paper presented at a recent general meeting in London of the Institution of Mechanical Engineers. The Authors at the time of preparing the manuscript were, respectively, liaison officer, British Non-Ferrous Metals Research Association; head of melting and casting BNFMRA, and director, S. Russell & Sons, Limited. Mr. Ruddle has since accepted a position in America with the Foundry Services' organization and Mr. Rice is now with Harlow Metal Company, Limited.

† An alphabetical list of references is given in an Appendix to the Paper.

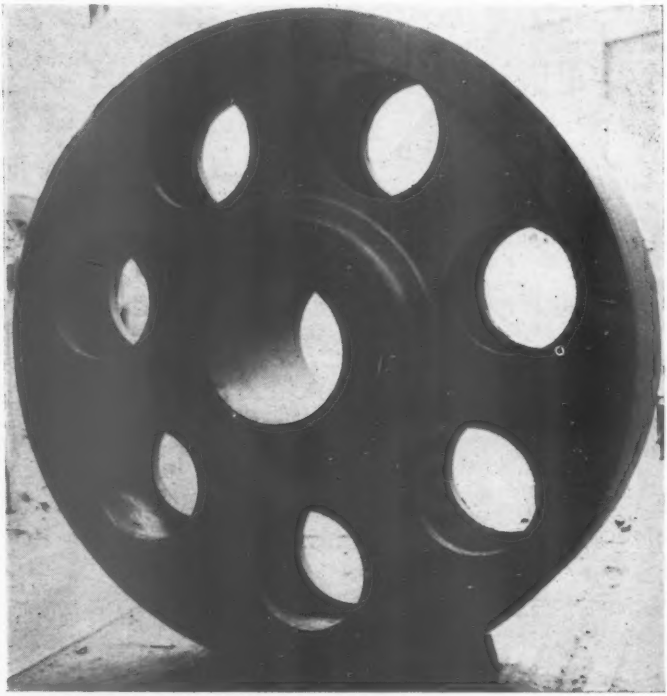


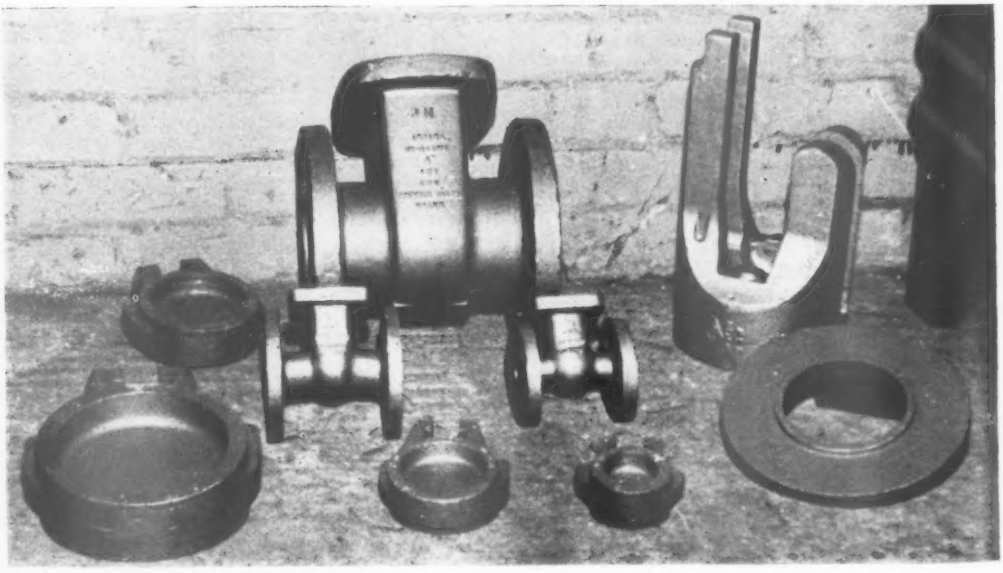
FIG. 6(*a*).—*Steel flywheel, weighing 6 tons, produced by the CO_2 Process.*

FIG. 6(*b*).—*Stainless-steel castings, made in CO_2-hardened moulds.*
(Courtesy of American Foundrymen's Society)

Precautions have to be taken to avoid sinks or depressions in the patterns due to the high shrinkage coefficient of the wax; sagging of the pattern can also give trouble. On these and other grounds, large castings are not normally made, and one foundry gives 8 lb. as the average weight of its precision-investment casts. With the "Mercast" process on the other hand, shrinkage is less and it is claimed (Kramer 1955) that casts of 300 lb. are in regular production. It therefore seems that the use of mercury is complementary to that of wax rather than competitive with it.

The high temperature to which the moulds are normally heated before casting, necessary if thin sections are to be run satisfactorily in high-melting-point alloys, results in a cooling rate in the casting slower than would be found in conventional moulding. Grain sizes in the "as-cast" state, therefore, tend to be large.

There appear to be no restrictions on the type of alloy which can be cast, but the process is not a cheap one and, unless dimensional accuracy is an overriding consideration, economics usually dictate the adoption of one of the other close-tolerance



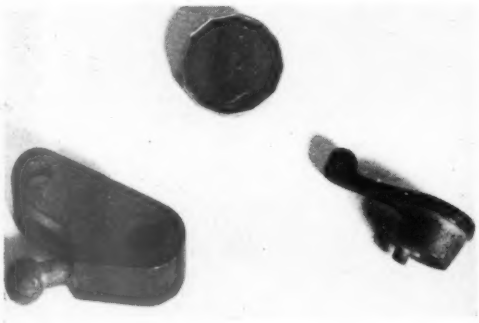


FIG. 7.—*Castings produced by the precision-investment process in* 3 *per cent. nickel case-hardening steel; left to tolerance of* ±0.002 *in. on the ball and, right, to* 0.001 *in. on the peg—used after hardening but no machining.*

casting methods. Typical precision investment castings are illustrated in Fig. 7.

Shaw Process

The Shaw process is a method of close-tolerance casting, not subject to the size limitations of wax-pattern precision investment casting and steel castings up to 3 cwt. in weight have been made successfully. It differs from the lost-wax process in that the mould is made in two halves. Dimensional tolerances are rather less close—about ±0.005 in. on dimensions 3 in. and under (Dunlop 1953)—but a great deal depends upon the design, since a joint line is unavoidable and this can cause inaccuracies.

Shaw-process moulds are made of a finely graded refractory, often sillimanite, which is mixed with ethyl silicate of controlled gelling power. The bond so formed is made up of hydrated silica, and an interesting feature of the process is that during gelation the rammed mass goes through a rubber-like stage. It is at this point that the removal of the pattern, which can be either of wood or metal, is most easily carried out since slight imperfections or undercuts on the pattern are then not deleterious. The interval between pouring the mould and casting it can be as little as one hour and the moulds are sufficiently permeable to permit the passage of mould gases. The process is one not easily mechanized and its main application would seem to lie in the small-quantity field where good reproducibility of an accurately made wooden pattern is required. The cooling rates in Shaw-process moulds are slow relative to green-sand moulds and the grain size is correspondingly large. All the usual casting alloys, both ferrous and non-ferrous may be made by the process and examples are shown in Fig. 8.

Semi-permanent Refractory Moulds

Special-purpose ethyl silicates have been used to bind a refractory such as sillimanite to form semi-permanent moulds. Such moulds have been used (Street, 1956) for aluminium where lives up to several hundred castings have been obtained, and for copper alloys where lives are shorter owing to the higher pouring temperatures involved. Such service is only possible if the moulds are carefully handled during use and is markedly affected by the casting design. Narrow recesses in the casting, involving fragile projections on the mould, inadequate taper, etc., all tend to reduce the mould life. It is also stated that beyond a casting weight of about ½ lb., mould life becomes undesirably short.

Little quantitative data is available about the dimensional accuracy obtainable and, since a metal pattern with its attendant cost is normally needed from which to prepare the original mould, the major application of the process is probably for non-ferrous alloys required in quantities which are too small to merit gravity-die-casting, or as an interim method of production until the manufacture of dies has been completed. As in the Shaw process and precision investment, cooling rates are slow and grain sizes correspondingly large.

Continuous Casting of Tin-bronze Stick

The continuous casting of tin-bronze stick, both solid and cored, by the "Asarco" process, has been in operation in the United States of America since 1947, but has only recently been introduced into Britain. The process employs a gravity feed of molten metal into a graphite die, the solidified stick being withdrawn by rollers from the bottom of the die. Similar principles have been used by Ellwood and his co-workers (Ellwood and others,

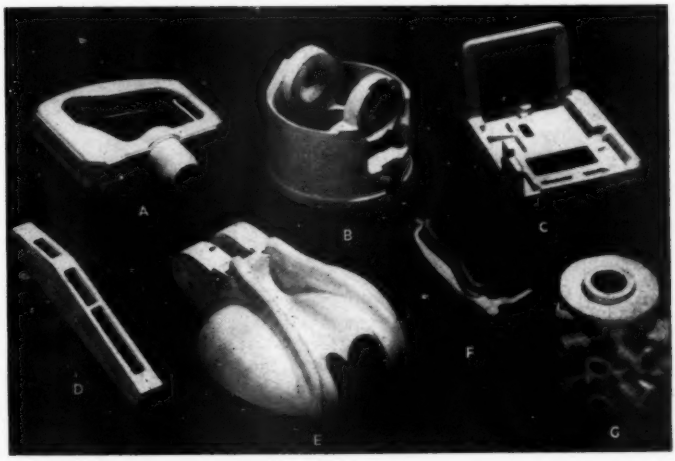


FIG. 8.—*Bronze and aluminium-alloy castings—examples of production by the Shaw process.*
(Courtesy of *Metal Industry*)

FIG. 9.—*Four-pinion differential cage for a tractor, made in pearlitic malleable iron.*
(Courtesy of Leys Malleable Castings, Limited)

1956) at the Tin Research Institute in the construction of simplified equipment capable of producing rod and tube up to 1⅝ dia.

The advantages claimed for continuously cast rod include improved density, virtual freedom from dross and blowholes, higher dimensional accuracy and improved mechanical properties. For tin bronze to B.S. 1400 PBI (10 per cent. tin, ½ per cent. phosphorus) Ellwood quotes mechanical properties of 25 tons per sq. in. tensile strength, and 20 per cent. elongation, compared with minimum specification values of 16 tons per sq. in. and 1.5 per cent. respectively. Such material promises to give the engineer improved bearing properties.

ALLOY DEVELOPMENT

Cast-iron

Grey Iron

Grey iron remains the basic material for most machines and, despite the introduction of fabrication and substitute materials, has more than held its own over the last 40 years. In this period, marked improvements have been made in strength and soundness. For example, in the first British Standard for grey iron in 1927 the highest grade had a tensile strength 12 ton per sq. in., by 1948 the specification contained seven grades, the highest having a tensile strength of 26 ton per sq. in.

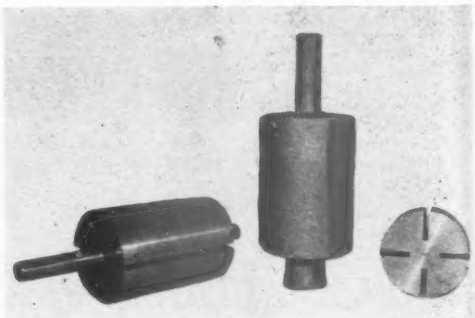
British development of grey iron has been hampered by the fact that most native iron ores contain considerable phosphorus, and in the presence of this element, it is difficult to increase the strength and soundness. Thus, for many years, most of the improvements in grey iron were along the lines of close analytical control of carbon and silicon used for medium and high-phosphorus iron, by means of which high strength and soundness could be obtained in castings of reasonably uniform section, but which often caused difficulties and disappointments in complicated casings. The use of inoculation by silicon in various forms, and of alloying elements, particularly nickel and/or copper, enabled the strength and soundness to be maintained over wider section differences. Other alloying elements used were chromium for the purpose of increasing heat- or wear-resistance, and molybdenum, the use of which up to 0.5 per cent. is valuable in increasing strength without varying the other properties to any considerable extent. Grey iron of the highest strength contains a combination of molybdenum with nickel to give an acicular structure. High strength can also be obtained by suitable heat-treatment, but complicated castings do not lend themselves, very well to this process.

Unfortunately, obtaining high strength and soundness by close analytical control of carbon and silicon involves rigid control of foundry operations, particularly melting practice. Any slight error in control can cause hard spots; also the general hardness level is high and this retards machining. Further, the presence of phosphorus *per se* introduces a hard constituent into grey iron, equally undesirable from the point of view of machinability.

Before 1945, the use of low-phosphorus grey-iron castings was mainly confined to the automobile industry, which had long recognized the value of this type of iron for the production of sound castings, and for the production of iron of higher tensile-strengths.

Comparisons of British and American practice made by the various Productivity Teams after the 1939-45 war showed that the American type of iron with phosphorus always below 0.5 per cent., and usually below 0.3 per cent., made possible higher cutting speeds than those normally employed in Great Britain. It was realized too that a grey iron of tensile strength, say 14 ton per sq. in., which gave a sound and uniform casting, was probably better in service than one that gave 20 ton per sq. in. in simple castings but which, unless great care was taken with foundry methods, was liable to contain unsound areas. Good impact-resistance in

FIG. 10.—*Pump rotor in spheroidal-graphite iron.*
(Courtesy of Birmidal Developments, Limited)



grey iron depends far more on a low-phosphorus content than a high tensile strength.

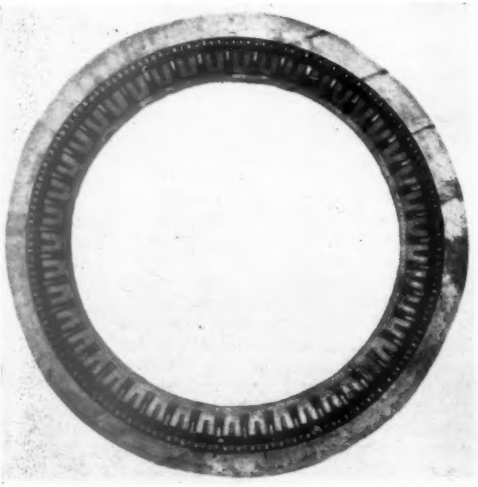
Many producers therefore changed to the low-phosphorus American type of iron which enabled much higher carbon and silicon contents to be used than previously, the Brinell hardness dropping by 20 to 40 points. Increases in cutting speeds of 30 to 50 per cent. have resulted from the use of this type of iron, together with the almost complete elimination of hard spots and porous areas. Typical feeds and speeds for rough machining low-phosphorus irons, provided the work can be rigidly held, are 250 to 280 ft. per min. with $\frac{1}{4}$ in. by $\frac{3}{32}$ in. cuts when turning with carbide tools, and 160 surface ft. per min. with $\frac{3}{16}$ in. cuts at 6 in. per min. when milling with high-speed-steel tools.

The advantages of this type of iron to the engineer are obvious, and its general adoption is limited only by the fact that low-phosphorus irons can be obtained only by the importation of iron ore or by the use of large quantities of steel scrap. There is some remaining prejudice that low-phosphorus iron will not wear so well in service, but when it is realized that practically all types of cylinder and also many of the highest grades of American machine tools have long been produced in low-phosphorus iron, this prejudice must soon disappear.

Malleable Iron

The main development in normal (ferritic) blackheart malleable castings has been toward improved uniformity and reliability of mechanical properties and also toward increased dimensional accuracy. This has been achieved by an increasing use of reverberatory and electric furnaces, to give better control of composition and casting temperature. Continuous annealing ovens and atmosphere-controlled radiant-tube and electric furnaces, by reducing annealing cycles to as little as 48 hr., have effected greater uniformity in the product.

FIG. 11.—*Precision-cast spheroidal-graphite iron tyre mould.*
(Courtesy of Birmidal Developments, Limited)



Pearlitic malleable iron is now produced with properties in the annealed condition in the range from 30 to 38 ton per sq. in. tensile strength, 20 to 26 ton per sq. in. yield strength, elongation 10 to 5 per cent., and hardness of 160 to 220 Brinell. Considerable use of these malleable irons is made in both the homogeneously heat-treated and in the selectively and surface-hardened conditions. The material readily responds to oil hardening and tempering, and tensile strengths of 50 ton per sq. in. with yield strengths of 30 ton per sq. in., are achieved. Surface hardening by flame or induction methods produce hardness of 700 V.P.N. A typical casting is shown in Fig. 9.

The principal technical advance in the production of whiteheart malleable cast iron has been the introduction of gaseous annealing. This has tended to reduce the time cycle involved in the production of this material and to improve the reliability of the product.

Spheroidal-graphite (Nodular) Cast Iron

Probably the greatest metallurgical development in cast iron in recent years has been the discovery by Morrogh and Williams (1948) of the British Cast Iron Research Association and by Gagnebin and others (1949) in the United States of America, of a method whereby the graphite present in ordinary grey cast iron can be made to assume a spheroidal form on solidification, as distinct from the nodular form that occurs in blackheart malleable iron as a result of heat-treatment. This has presented the engineer with a material with a whole new range of properties. This material has already been described to the Institution of Mechanical Engineers by Bailey (1954) and in various papers to the Institute of British Foundrymen and other technical bodies. Braidwood (1956) gives considerable information on the latest methods of production and the many applications. These irons are generally known either as s.-g. iron or nodular iron. and, in the United States of America, as ductile iron.

The recently published B.S. 2789:1956 lists two main types of this iron: type (1) is the fully pearlitic material with a minimum tensile strength of 35 ton per sq. in.; type (2) is available in two conditions, both ferritic. Minimum properties of type (2)A are tensile strength 27 ton per sq. in., 0.5 per cent. proof stress 18 ton per sq. in., and elongation 12 per cent. The minimum properties of type (2)B, which is designed to meet the demand for especially high impact-resistance, are tensile strength 24 ton per sq. in., 15 ton per sq. in. proof stress and 17 per cent. elongation. This last material must also withstand 10 ft.-lb. on the standard 0.45 in. notched Izod test. Type (2)A has an optional Izod test of 6 ft.-lb. In addition to the grades covered by this British Standard, alternative intermediate grades are available. S.-g. irons are also frequently used in the heat-treated condition; whilst in the early stages of development the principal uses of s.-g. irons were thought to be in the "as-cast" condition, present experience is that the bulk of

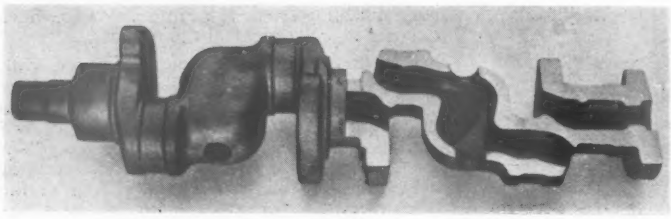


FIG. 12.—*Crankshaft for Taunus engine.*
(Courtesy of Mond Nickel Company Limited)

this iron is being produced in the annealed condition of type (2)A.

The principal claim for the material is that the advantages of cast iron as regards rigidity, ease of cutting, good appearance and the self-lubricating properties associated with graphite are combined with strength properties similar to those of steel; yet the drawbacks of cast iron, particularly its brittleness, are removed. Applications of this material can best be described by illustrations of actual products, principally to show the economy in production costs obtainable by the use of this material.

Fig. 10 shows a commercial pump rotor in which a s.-g. iron casting has replaced a separately cast body which was bored and keywayed to receive a steel shaft. Much machining has thus been eliminated and, in the fully annealed condition, these castings machine very readily; the cutting of the slots, for example, was done to full depth at a feed rate of just over 6 in. per min.

Fig. 11 shows a large precision-cast tyre-mould of approximately 40 in. dia. in which the tread patterns are precision-cast by an investment process. S.-g. iron was used because it gave an excellent skin finish and also enabled the rings to be "sized" by expanding or compressing slightly to bring the diameter to a dimensional tolerance ± 0.015 in. These moulds are also considerably stronger than the precision-cast aluminium moulds previously used.

FIG. 13.—*Sump casting in spheroidal-graphite iron*
(Courtesy of Lloyds (Burton), Limited)

Fig. 12 illustrates the hollow crankshaft used in the German Ford "Taunus" engine. This is obviously of lighter weight than a shaft produced from forged steel and, compared with the forging, machining allowances are also reduced.

Further illustrations show applications made possible by the special properties of the material. A diesel engine sump (Fig. 13) produced in annealed s.-g. iron, shows the type of complex casting of thin section that can be produced. Fig. 14 shows a filter cover, originally designed for production in bronze. This is threaded 3 in. B.S.P. without difficulty and afterwards pressure tested.

S.-g. iron is proving of particular value in the production of airborne gas turbines, as it can be run into comparatively thin sections, and an example of this was given by Bailey (1954). Fig. 15 illustrates a rear-bearing housing of a high-performance gas-turbine engine fitted to various fighter aircraft, made in fully annealed s.-g. iron, and Fig. 16 shows various types of hot-air valve bodies used with gas-turbine engines to control the flow of air from the compressor to the cabin heating and de-icing equipment on aircraft. They operate in service at 450 deg. C. and 150 lb. per sq. in. Wall thicknesses are a nominal 0.110 in. running into thicker flanges and bosses. These castings are supplied in the normalized condition to a specification of 45 ton per sq. in. tensile strength of 5 per cent. elongation.

S.-g. iron is also being used for the heavier type of stator casting for axial compressors for land or marine turbines, where it appears to combine the qualities of heat-resistance and rigidity in service. In this context the following may be quoted:

> "We have recently made a dimensional check on the diameters of the stator casting supplied in s.-g. iron. Machining, fitting, etc., was completed on September 27, 1955, since which date the form of the casing has not been touched. Our inspection, which was carried out on February 17, 1956, shows the casing to be 0.002 in. out of round at the inner end, *i.e.* the large end, and no discrepancy at the outlet end. The fact that two heavy casings of such a size and shape should maintain such close stability over a period of five months is remarkable, as the movement of compressor casings after manufacture is a serious problem."

Fig. 17 shows one half of this casing. The rough casting weighed approximately 5 cwt.

These examples give only a scanty indication of the very wide field of application of s.-g. iron, which includes heavy castings and rolls. Reference has already been made to the machining properties of the low-phosphorus type grey cast iron. Blackheart malleable iron, in the recent

FIG. 14.—*Spheroidal-graphite iron filter cover.*

developments in the manufacture of castings ferritic conditions, is well known to be the most freely machinable of all cast ferrous products, but s.-g. iron (annealed) also machines remarkably freely, cutting speeds of 500-700 ft. per min. being common. The pearlitic grades of both blackheart malleable and s.-g. iron are more easily machined than steel of corresponding hardness.

Copper-base Alloys

Few major developments have taken place in copper-base alloys in recent years and in fact only one really novel material has been developed to the point of production. Nevertheless, during the period under review, minor modifications to alloy compositions and the development of little-used alloys, together with increased use of hitherto little-used alloys, have to some extent changed the pattern of copper-alloy production.

The new alloy is an alloy of the aluminium-bronze type containing 10-15 per cent. manganese, 6½-9 per cent. aluminium, 2-4 per cent. iron, and 1½-6 per cent. nickel (British Patent 1955). This alloy, which is primarily intended for the production of marine propellers, combines high strength with exceptional resistance to corrosion. The latter property depends upon the nickel content, alloys containing about 2 per cent. nickel having a moderate degree of corrosion resistance and those containing about 5 per cent. being equal to that of the best manganese-free aluminium-bronzes. The alloy has a 0.15 per cent. proof stress of 18 tons per sq. in., a tensile strength of 42.5 tons per sq. in., and an elongation of 28 per cent. The fatigue strength is high, being equal to the proof stress. This material appears so far to have been used only in the application mentioned above but its use is likely to spread to other heavy castings for which it is said to be especially suitable.

TABLE IV.—*Nominal Composition of Ni-Vee Bronzes.*

Type.	Copper.	Nickel.	Tin.	Lead.	Zinc.
A*	88	5	5	0	2
B*	87	5	5	1	2
C	80	5	5	5	5
D	80	5	5	10	0
E	70	5	5	20	0

* Meets A.S.T.M. designation: B292-54T.

Various advantages have been claimed for the additions of nickel, which from time to time have been made in some foundries, to the standard bronzes. In particular it has been known for some time that additions of the order of 5 per cent. nickel yield alloys which are amenable to age hardening and during the last few years the use of these alloys, now developed to a considerable degree of perfection, has been increasing in the United States of America (Roast, 1953). At present the five compositions indicated in Table IV are in common use.

The mechanical properties of these alloys are shown in Table V and a stress/strain curve of a typical composition is compared with curves for several copper alloys in Fig. 18. In addition to their excellent room-temperature properties the alloys have good properties at elevated temperatures and excellent wear and corrosion resistance. Of the five alloys listed in Table IV the first two are recommended for constructional purposes and for the manufacture of gears and other parts which must resist wear. Alloy C is an alloy specially developed for resistance to high pressures, and the last two compositions are leaded alloys intended for the manufacture of high-quality bearings.

Nickel, as mentioned above, is also being added in small quantities (about 2 per cent.) to the conventional bronzes. Various claims have been made for these additions such as decreased grain-size and improved corrosion-resistance (Roast 1953; Vannick 1950), but the evidence on the former point does not appear very conclusive. It has also been said (Pfeil, 1954) that addition of nickel improves the mechanical properties of bronze when this is cast in relatively heavy sections; normally bronzes and gunmetals when cast in heavy sections have extremely poor mechanical properties. The use of the nickel/antimony/lead-bearing bronzes developed in Canada (Roast, 1953) is also tending to increase, these alloys containing 10 per cent. of lead with 1 to 8 per cent. of antimony and 2 to 8 per cent. of nickel; the sum of the nickel and antimony contents is usually about 9 to 10 per cent.

Silicon brasses have been known for many years and are widely used in the United States for the manufacture of die-castings. Recently several authors have recommended their use for pressure-tight sand castings, for which they are said to be extremely suitable on account of their high fluidity. These sand-casting alloys contain considerably less copper (50 to 60 per cent.) than those used in die-casting (Daase, 1950; Pelzel, 1953).

The use of copper and lead alloys for bearings continues to increase and several methods of improving the lead distribution and hence the bearing properties have been introduced during the last

few years. These methods include addition of Sulphur (Ruhenbeck, 1951), or calcium (British Patent 700 035), or subsequent heat-treatment (British Patent 699 097).

Beryllium-copper is another material, long established in wrought form, which is now being applied to the casting of non-sparking tools and in the production of small components to accurate dimensions by investment casting techniques (Richards, 1951). These alloys have tensile strengths between 50 and 70 tons per in. with hardness numbers up to 420 V.P.N. (Hildebrant, 1950).

Aluminium Alloys

Few startling developments have taken place in aluminium casting alloys in the last decade but steady progress has been made in alloy development and this has resulted in the introduction of a number of alloys which are essentially modifications of existing compositions rather than new alloys; B.S. 1490:1955 incorporates the latest revisions.

Of the four new alloys introduced (Table VI), LM21 is closely similar in composition to the popular alloy LM4, the only difference being that the permissible zinc limit has been raised from 0.5 to 2.0 per cent. The need for this has arisen because of the large quantities of high-zinc scrap available as a raw material from which it is difficult to produce LM4. The specified mechanical properties of both alloys are similar, except that the minimum elongation of LM21 is 1.5 per cent. instead of 2 per cent. Prior to the introduction of LM21, extensive tests were made by the British Non-Ferrous Metals Research Association and Alar, Limited, to confirm that raising the zinc content does not impair the ductility or other properties.

LM22 is another variant on LM4, the difference here being that the permissible magnesium content has been reduced from 0.15 to 0.05 per cent. LM22 is intended to be used in the fully heat-treated condition and the reduction in magnesium content has been specified to render the response to heat-treatment reproducible and also to prevent heat-treatment from lowering the ductility to too great an extent. The content of other impurities such as nickel, lead, etc., are also lower than in LM4. Alloy LM22 is intended mainly for the manufacture of gravity-die-castings.

LM23 is essentially a development of the copper/silicon alloy LM7 and this variant has also been produced in order to obtain a consistent response to heat-treatment. The heat-treated version of LM7 has been deleted from the specification.

LM24 is a new composition in Britain although it has been known as S.A.E. 306 in the United States for some years and has been extensively used there in the manufacture of pressure-die-castings. This alloy is capable of yielding a tensile strength of 18 tons per sq. in. with 3 per cent. elongation when chill cast. The composition and properties of these four new alloys together with those of LM4 and LM7 are summarized in Table V. Attempts further to improve the properties of aluminium/copper/silicon alloys have recently been described by Colwell and Trela (1954) and Bertram and others (1956).

In the last 10 or 15 years, considerable interest has been shown in the United States and on the Continent in the properties of the aluminium/zinc/magnesium casting alloys, a number of compositions having been developed and which are in fairly regular use in some foundries. The best known of these is probably Frontier 40E (ASTM specification B26/55T ZG61A) the percentage composition of which is 5.2 to 6 of zinc, 0.5 to 0.65 magnesium, 0.4 to 0.6 chromium, 0.3 manganese, 0.25 silicon, 1.0 iron, and 0.3 copper. The specified strength figures for this material after artificial aging only, are 0.2 per cent. proof stress 11.2 tons per sq. in., tensile strength 14.3 tons per sq. in., and elongation 3 per cent. Slightly higher figures are obtained in certain other alloys of closely similar composition. These alloys, in addition to the high strength obtainable on natural or artificial aging also have good resistance to corrosion and, although 40E alloy is now available in Britain, it may be argued that insufficient attention has been devoted to them here. However, alloys of this group have relatively poor casting characteristics, being very prone to shrinkage porosity and hot-tearing. Furthermore, some compositions are known to be susceptible to stress corrosion and this may have made manufacturers in Britain hesitate to adopt even the better alloys. Development work on alloys of this type has recently been described by Grand (1953), Bonsack (1950), and Sicha and Hunsicker (1950).

Efforts have recently been made in the United States to improve the properties of aluminium/silicon/magnesium alloys basically similar to LM8, and Lemon and Hunsicker (1956) have described the properties of two new compositions, C355 (1.3 per cent. copper, 5 per cent. silicon, 0.5 per cent. magnesium) and A356 (7 per cent. silicon and 0.3 per cent. magnesium). Chill-cast test-bars of these alloys have strengths in the fully heat-treated condition of respectively 23 and 18 tons per sq. in.;

TABLE V.—*Typical Mechanical and Physical Properties of Nickel Bronzes.*

Type.	A.		B.		C.			D.		E.	
	As-cast.	Tempered.	Heat-treated.	As-cast.	Tempered.	As-cast.	Tempered.	As-cast.	Tempered.	As-cast.	Tempered.
Tensile strength, tons per sq. in. ..	22	29.0	37	20	27	18	22	16	18	11	13
Yield strength, tons per sq. in. ..	10	18	25	9	13	9	13	9	11	8	10
Elongation, per cent. on 2 in. ..	40	10	10	30	8	15	5	10	2	5	2
Brinell hardness	85	130	180	80	120	80	130	80	110	70	80
Modulus of elasticity, lb. per sq. in. × 10^6	15	—	15	13	14	12	13	11	12	10	11
Toughness, standard Izod, ft.-lb. (un-notched)	85	80	110	—	—	65	12.0	—	—	—	—
Density, lb. per cub. in.	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.33	0.33	0.34	0.34

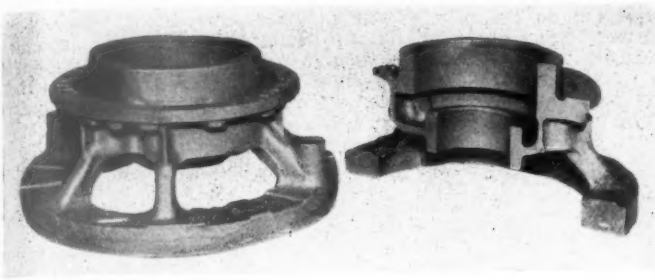
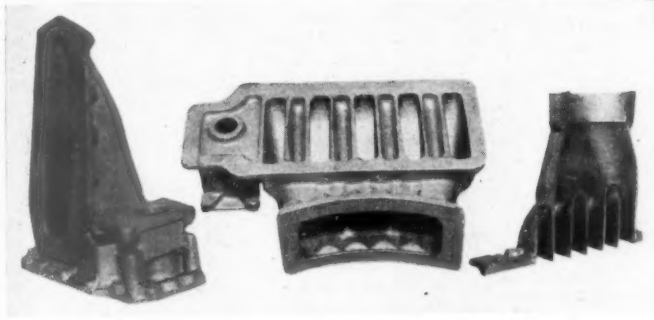


FIG. 15.—*Rear-bearing housing.*
(Courtesy of Birmidal Developments, Limited)



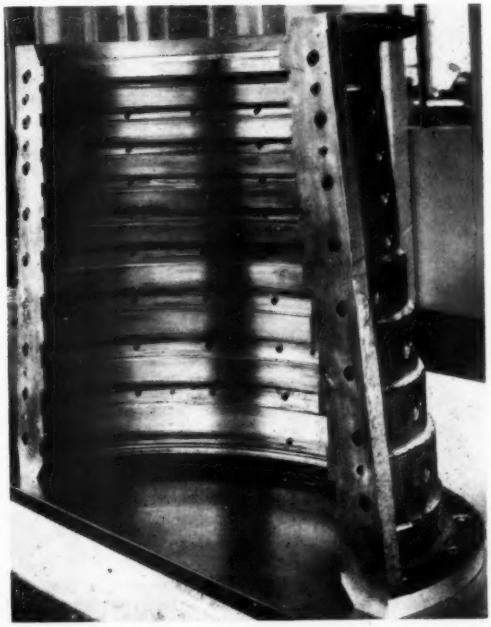
(Courtesy of Birmidal Developments, Limited)
FIG. 16.—*Hot-air valve bodies.*

the respective elongations are 4 and 10 per cent. Considerable research has been devoted to the development of new alloys for pistons for internal-combustion engines and a very large number of compositions have been mentioned in the literature during the last 5 to 10 years. The most interesting of these appears to be the high-silicon group of alloys. Alloys in this group contain 18 to 24 per cent. of silicon together with smaller amounts of nickel, iron, magnesium, copper, and other additions. These alloys seem to have been largely developed in Germany and numerous references to their properties and manufacture appear in the literature (Wagner, 1947; Barsack, 1950; Onitsch-Modl, 1951; Neu, 1954; Thurry and Kessler, 1956). They are claimed to be lighter and stronger than the alloys at present in general use and to possess better properties at elevated temperatures, lower thermal expansion and excellent wear-resistance. The tensile strength of the die-cast alloy is about 13.5 tons per sq. in. and the coefficient of thermal expansion is 17.8 $\times$ 10^{-6} in. per in. per deg. C. On the other hand, Bonsack (1950) states that the high-silicon alloys have poor castability, are difficult to machine, and that their low thermal-conductivity results in operating temperatures higher than those obtaining in pistons in normal materials. Bonsack also considers that the necessity for a high casting-temperature lowers the rate at which pistons can be produced.

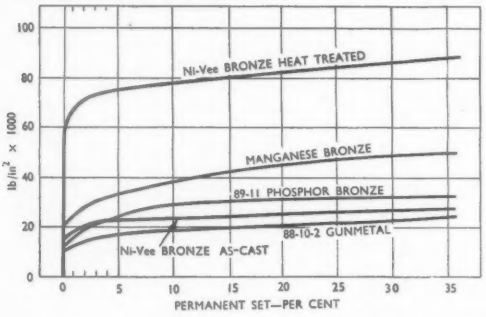
Difficulties are also met in the distribution and size of the silicon particles in these alloys, but these are in process of being surmounted (Wagner, 1947; Onitsch-Modl, 1951; Neu, 1954; Thurry and Kessler, 1956; Mascré, 1953), and the alloys are now being used in the commercial production of pistons in several German foundries (Bücken, 1956) and production in Britain is believed to be imminent.

Another development of importance in aluminium casting alloys results from work carried out at the Fulmer Research Institute on the effect of certain additions, notably cadmium, in aluminium/4½ per cent. copper alloys (essentially LM11). The addition of 0.1 per cent. cadmium enables the tensile properties in the fully heat-treated version of this alloy to be raised to the following figures: proof stress 22½ tons per sq. in.; tensile strength 25 tons per sq. in., elongation 1.2 per cent. (Liddiard and Hardy, 1954). So far, only a limited amount of

FIG. 17.—*Spheroidal-graphite iron stator casing.*



development work has been carried out on the manufacture of castings, but there would seem to be a definite application in the production of castings of really high strength, in particular for aircraft. Aluminium/copper alloys are, however, not popular in the founding industry on account of their poor casting properties.



(Courtesy of International Nickel Company)

FIG. 18.—*Stress/strain curves of Ni-Vee bronzes compared with other copper alloys.*

The use of aluminium alloys as bearing materials has been increasing in recent years. Alloys used in this application include aluminium/silicon alloys of the "Lo-Ex" type, the high-silicon alloys referred to above, alloys containing cadmium, antimony, and lead, and alloys containing tin; in Britain and the United States alloys in this last group are favoured and two groups of aluminium/tin alloys have been developed. Alloys in the first group contain 4½ to 7 per cent. of tin together with up to about 1 per cent. of nickel and of copper/silicon, antimony, manganese, and magnesium are also present in some compositions. The second, more recently developed group of aluminium/tin alloys contain 30 per cent. of tin, plus hardening element such as copper (Liddiard, 1955). These alloys possess the disadvantage that they must be cold-worked and annealed, but after this treatment have excellent bearing properties, their load-carrying capacity and fatigue strength being substantially greater than that of the ordinary tin-base Babbitt alloys and can exceed those of the copper/lead alloys.

Another bearing alloy which, although having zinc as its major constituent, is most conveniently discussed here contains 30 to 40 per cent. aluminium and 5 to 10 per cent. copper. The alloy can be both gravity- and pressure-die-cast and its boundary-lubrication characteristics are claimed to be particularly good. A test run with the dry bearing showed that seizure did not occur until a temperature of 400 deg. C. was reached and even then no welding to the shaft took place.

Although it has been realized by many for a long time that the properties obtained in sand-cast test-bars are not necessarily representative of those of the casting, designers have generally, nevertheless, employed test-bar properties in computing the stresses present in their structures. Probably the main reason for this is the fact that little qualitative information exists about the properties to be expected in castings as distinct from test-bars, and it is therefore gratifying to note that two papers have recently been published in which the strength of aluminium castings themselves are correlated with those of the accompanying test-bars (Slachta and Mansfield, 1955; Taine and Stewart, 1955). Work of this kind is greatly needed so that designers can employ figures more representative of those obtaining in the casting itself.

(To be continued)

TABLE VI.—*Compositions and Properties of New Aluminium-alloy Specifications.*

Alloy.	Composition, weight per cent.										Condition.	Tensile strength, per sq. in.	Elongation, per cent on 2 in.
	Copper.	Magnesium.	Silicon.	Iron.	Manganese.	Nickel.	Zinc.	Lead.	Tin.	Titanium.			
LM4	2.0–4.0	0.15	4.0–6.0	0.8	0.3–0.7	0.3	0.5	0.1	0.05	0.2	M { S	9.0	2
											M { C	10.0	2
LM7	1.0–2.5	0.05–0.20	1.5–3.5	0.3–1.4	0.1	0.5–1.7	0.1	0.05	0.05	0.05–0.30	M { S	9.0	2
											M { C	10.0	2
LM21	2.0–4.0	0.15	4.0–6.0	0.8	0.3–0.7	0.3	2.0	0.1	0.05	0.2	M { S	9.0	1.5
											M { C	10.0	1.5
LM22	2.8–3.8	0.05	4.0–6.0	0.7	0.3–0.6	0.15	0.15	0.05	0.05	0.2 +niobium	W { S	16.0	8
											W { C	—	—
LM23	0.8–2.0	0.05–0.20	1.5–2.8	0.8–1.4	0.1	0.8–1.7	0.1	0.05	0.05	0.05–0.30 +niobium	P { S	10.0	2
											P { C	12.5	3
LM24	3.0–4.0	0.1	7.5–9.5	1.3	0.5	0.5	1.0	0.3	0.2	—	M { S	—	—
											M { C	11.5	1.5

M As-cast. S Sand-cast. C Chill-cast. W Solution-treated and aged. P Precipitation heat-treated.

F. PERKINS, LIMITED, Peterborough, has received an initial order for its new Four 99 (TA) diesel engine, from Epple-Buxbaum-Werke, of Wels, Austria. The company has also announced the placing of initial orders for agricultural engines by one German and three Argentine concerns.

SWITCHGEAR AND TRANSFORMER PLANT for the pumping operation of the Lake Maracaibo, Venezuela, oil drilling project, which is being launched by the Shell Petroleum Company, Limited, is being supplied by South Wales Switchgear, Limited. The order is worth more than £500,000.

American Engineers discuss Foundry Subjects

Report of ASME Fall Meeting

(Continued from page 644)

Continuing the series of abstracts from papers read at the Fall Meeting of the American Society of Mechanical Engineers held at Harford, Connecticut, recently, the following article gives details of five further papers of major technical interest which were presented on that occasion.*

A Commercial Cast Steel†

By C. G. Mickelson and R. D. Engquist

The authors, who are associated with American Steel Foundries, explained that a strong, hard abrasion-resisting steel was desired, one of the principal uses of which was for handling Taconite ores in the Northern US mining areas where low temperatures in the winter were encountered. For this a hard, tough material with a high yield strength was necessary, one which would have an impact resistance suitable for temperatures as low as −50 deg. F.

In this service soft work hardenable manganese-steel was inadequate and white cast iron, although hard, would be too brittle. The need had led to the development of a steel of approximately 0.23 to 0.33 carbon; 1.3 to 1.8 manganese; 0.30 to 0.60 silicon; 0.40 to 1.00 chromium; 0.40 to 0.60 molybdenum; and 0.50 per cent. nickel (max.), which also contained some boron. This steel, when quenched and tempered into the hardness range of 250 to 500 Brinell, would develop a tensile strength of 54-110 tons per sq. in., a yield strength of 50-85 tons per sq. in. and an elongation of 50 to 20 per cent. and a reduction of area of 20 to 10. Its impact resistance at 250 BHN was 80 and at 400 BHN was 20. At −40 deg. F., it was 15.

The steel was hardenable for a depth of 1 to 2 in. It was considered usefully hard, up to thicknesses of 4 in. and work was in progress to achieve hardenability up to an 8 in. thickness.

A notched static tensile strength of 135 tons per sq. in. was found with a 60 deg. V notch 0.065 in. deep while a true tensile strength of 138 tons per sq. in. was obtained, indicating a ratio of unnotched to notched tensile strength of 1:33.

At subnormal temperatures the transition occurred at about −175 deg. F. with a hardness of 477 BHN. The impact values given were as follow:

Impact	Temperature
20 ft./lb.	0 deg. F.
16 ft./lb.	−150 deg. F.
8 ft./lb.	−250 deg. F.
4 ft./lb.	−350 deg. F.

At elevated temperatures the impact strength was retained for 250 hour heatings at temperatures up to 371 deg. C.

Impact 20 ft./lb. at 148 deg. C.
16 ft./lb. at 260 deg. C.
14-16 ft./lb. at 371 deg. C.

Its fatigue strength compared favourably with wrought steels. In a test on polished specimens the fatigue strength would run as high as 32.4 tons per sq. in. while a notched specimen failed at 23.6 tons per sq. in. showing a ratio of 1:375 of unnotched to notched material.

The alloy was magnetic and this helped to eliminate tramp metal from ceramics or crushed minerals during the processing of ores.

Its machinability was stated to be similar to that of an SAE 4340 steel (0.40 C, 1.75 Ni, 0.80 Cr, 0.25 Mo) at 500 BHN.

In the foundry it cast as a 0.30 carbon intermediate managanese-steel would; it possessed a normal shrinkage and appeared to be less susceptible to hot tearing than is common for steels of high hardness. It was weldable under controlled conditions using stainless steel or alloy steel electrode with a pre-heat of 150 deg. F.—148 deg. C.—and could be welded for fabrication in the field. Its applications included tractor treads, sprocket gears and the possible application in auto or aero fields for which it could be attractively processed by precision or semi-precision methods.

Specifications as Related to Design Quality in Steel Castings

By David Zuege

The author, who is technical director of Sivyer Steel Castings Company, pointed out that specifications differed in that while the national specifications were wider in scope, manufacturers' specifications were generally finer in detail. Misunderstandings could develop through the use of unnecessary refinements such as magnetic particle and radiographic inspection unless private manufacturers took the trouble to waive these requirements for castings which did not need them. The foundryman could devote his attention to improving the integrity of the casting for the purpose it was intended to serve.

Mr. Zuege went on to say the American Society for Testing Materials, a national body, and the Society of Automotive Engineers, a corresponding one, employed about eight general specifications covering 44 grades of low-alloy and plain-carbon steel. In addition to this, government specifications brought in additional requirements which involved revisions to the national specification or the detailing of special-purpose applications. A typical example was a specification for aircraft steel castings, involv-

* It is understood that copies of the full text of the papers are obtainable from American Society of Mechanical Engineers, Order Department, 29, West 39th Street, New York 18, NY.

† An abstract of the authors' paper "Steel Castings which are Resistant to Wear and Impact" appeared in the JOURNAL on August 15, 1957.

ing tensile strengths in the range of 53-78 tons per sq. in. Finally, there were private specifications used by individual manufacturers which were noted for being more confining and correspondingly more restrictive than those mentioned above.

Many of the specifications possessed overlapping mechanical properties, particularly in the 27-31 tons per sq. in. tensile-strength grades. They might bring in additional specification requirements as indicated in ASTM E109-55T on magnetic particle inspection or E105-56T on sampling. They might specify hardenability or require that decarburization should not penetrate more than 0.01 to 0.03 inches below the surface. They might place fine limits upon the presence of contaminants and the fine control required for narrow composition limits could affect the mechanical property values which the ASTM specification defined. Some specifications contained limits upon the maximum hardness acceptable when welded and required a weld bead test for check-up. Others attempted to define this type of requirement by calculation from the composition or analysis. There were, too, additional details involving the repair of weldable defects and allowable preheating and postheating procedures. Some of these requirements were perhaps justifiable; others merely decreased productivity and increased the cost. The Steel Founders' Society had prepared a compilation of specifications which was available as a reference source.

Some engineers believed that specimens cut from castings should pass the specifications. In these cases the mass effect and corner effects were ignored and attention had to be called to the fact that an 8 in. × 8 in. section would not deliver the properties expected in a 1 in. × 1 in. section. There was, he pointed out, a solidity-factor related to the geometry and section-thickness of the casting and this factor could be explored in the case of small castings by loading them to establishing their strength, locating areas of weakness and correct inherent defects by employing foundry methods such as padding, chilling, risering or controlling the location of centreline shrinkage. This work was more readily accomplished in the case of production lots where the repetitive practice in producing castings could be evaluated by cutting specimens from them. The results applied where the casting section and similar geometry prevailed. The radiography of castings should be settled between producer and consumer by establishing where and how much stress would occur.

The author concluded by reporting that: (1) Specifications of the national bodies were abreast of modern developments. He recommended them to the design engineer. (2) Specifications which involve more restrictive requirements were sometimes justifiable but not always so. (3) If restrictions increased, the testing and explorations required would increase costs. (4) Specification values could be used for design purposes but not all parts of a casting could meet them. (5) Non-destructive testing provided the necessary insurance to assist in producing a more satisfying job. (6) In all cases co-operation between the designer and the foundryman was desirable to establish the important and less important positions in a casting, so that greater reliability could be built into the job.

Discussion by designers made it clear that they wanted consistency and reliability in the products which they specified and that they could not afford to spend much of their time in attempting to evaluate weaknesses. Their problems were multiplied by "pyramiding" thermal and frictional stresses into the structure. Further discussion brought out the fact that magnaflux patterns in inspection could become misleading and so required definition.

Development and Testing of Magnesium alloy Wheels

By R. L. Atkin and John G. Mezoff

The authors described experiments on cast, dishpan-shaped wheels for a 2½-ton capacity vehicle. Various mechanical means, such as adding thin and thick ribs (as well as in wave type ribs, were employed to develop a design. A magnesium alloy described as AZ81-T4, which was sand-cast and subsequently heat-treated, was to be the construction material. Its composition was nominally 7.6 aluminium, 0.7 zinc, 0.13 manganese, balance magnesium. Its mechanical properties heat-treated were in the range of 17.9 tons per sq. in., tensile strength 4.5-5.8 tons per sq. in., yield strength, 12 per cent. elongation, with a modulus of 6½ million lbs. Fatigue tests on castings were made on full scale wheels equipped with rubber tyres and tested under load on machines similar to those used for tyre testing. The preliminary tests revealed several areas of weakness relating to the hand-holes and contour of the dishpan-shaped wheel centre.

Strain gauge tests on wheel surfaces indicated that loads could exceed 5.4 tons per sq. in. and failures usually occurred in the fillet joining the flange and plate sections of the wheel. The authors used facsimile specimens of this area to develop fatigue-limits under the reverse bend tests. Failures occurring at 4.9 tons per sq. in. in 5-million stress cycles were improved to a level of 7-8 tons by cold-rolling the fillet area to densen and strengthen this position. The force applied for this purpose, the rate of application and the diameter of the roll were all important details.

The authors further reported that, when loaded to produce uni-directional stress, the fatigue-limit could be increased to as much as 9.8 tons per sq. in. The exploration in this case led to the successful production of light weight alloy wheels each at a finished weight of 36 lbs. which were to replace pressed steel wheels weighing 77 lbs. each, representing a reduction of 53 per cent.

During the discussion questions were raised regarding quality control which the authors explained would be dealt with by means of X-ray and liquid penetrants. Test bars would be cast separately and checked with each heat to establish the effectiveness of the heat-treatment. Reference to hot-tearing brought out the point that the AZ81 alloy was less

susceptible to this damage than others of the magnesium family.

With regard to whether permanent mould castings would develop better mechanical properties, it was made clear that properties would be nearly alike. The economy of magnesium as compared to pressed steel was justified for military vehicles requiring light weight in which the cost of air lift weight was worth as much as 3½ to 10s. per lb. and the substitution of magnesium for steel in these cases was believed to be practicable.

General Design Considerations for Smaller Gas Turbines

By W. T. Von der Nuell

In a review the author, speaking of materials and manufacturing, mentioned that the future of the smaller gas-turbine depended at least as much on the development of better materials as did that of the big units and possibly even more so in that the cost of materials and simpler ways of shaping them might be a more critical issue when smaller units became a mass-produced item for industrial and automotive power. Basically, for the components of the turbine proper, structural materials having high strength at high temperature with satisfactory resistance against scaling and corrosion were needed and, for the rotating parts, the best possible ductility was required. Good elongation was essential, he said, because in highly-stressed rotating parts, particularly with asymmetrical shapes, it allowed for some stress-equalization.

He went on to describe Inconel 713C, a nickel-chromium cast alloy with strength up to 926 deg. C. and good resistance to thermal fatigue which, because easy to cast, was considered attractive for gas-turbine blades. It contaned no cobalt but 1-3 per cent. Cb + Ta. As investment-cast material, it was used in the as-cast condition without subsequent heat-treatment; it was not available as wrought material.

The strength and elongation properties at higher temperatures, he said, especially at 926-972 deg. C., were a significant property of the alloy. As was well known, the properties of high-temperature alloys were affected by the melting procedure, the fabrication, and the heat-treatment used. And, since higher operating temperatures would always be attractive for high-performance gas turbines, the metallurgist was continuously searching for better superalloys. The higher rupture strength of vacuum-melted alloys was partly attributed to the possibility of higher titanium and aluminium contents. Rupture stress, rupture time, and elongation had been improved.

Newer cast alloys were now appearing and the possibilities of using precision-cast high-temperature alloys would be known to all. Cast individual blades and complete blade rings were being used in axial turbines and compressors. Precision-cast gas-turbine exducers as well as complete one-piece radial wheels had been accepted widely, especially in exhaust turbochargers with inlet-gas temperature up to around 760 deg. C. The author still had some misgivings about cast hot wheels. Whereas with the forged wheel the soundness of the forging could be inspected to a high degree through, for instance, ultrasonic methods by which unacceptable discontinuities within the material reflect the sonic beams as "echo signals," an equally reliable way of checking the soundness of a casting had not come to his attention.

Since turbine wheels usually give little or no warning of impending failure, protective provisions of some sort had to be deemed indispensable. Exploding automotive torque converters were unfortunate; an exploding turbine wheel could be catastrophic. Where weight and space and cost conditions permitted, a "solid" casing capable of unconditional containment could be an acceptable but not always simple solution. At any rate, quality control had not often been so specifically a matter of protecting human lives as it was in hot, high-speed turbomachinery. He stressed that extensive creep-rupture investigations of materials should be continued. Aluminium in cast or wrought condition, he pointed out, was being improved continually and remained a favoured material especially for compressors. Needless to say the designer would always wish for improved magnesium alloys and read with delight that the application of certain cast magnesium alloys had "resulted in burst speeds in excess of 2,000-ft. per sec." in compressor development work.

Machining Heavy Steel Castings

By J. H. Ferrell

The author emphasized the need to plan the production of extremely large and heavy steel castings in a manner which accommodated the equipment to be used for handling, machining and transporting the casting. He referred to the need to know the centre of gravity of the mass and to provide locating pads from which to conduct measurements and to incorporate hoisting lugs for moving heavy castings. He mentioned cable saddles for suspension bridges in the form of castings 7 ft. × 6 ft. × 15 ft. long, weighing from 5 to 45 tons and finished to a slick surface incorporating troughs, 24 in. in diameter, smoothly polished to carry the suspension cable. Such castings and their accompanying heavy weights, like hydraulic cylinders for presses and extrusion machines, plus rolling-mill housings, represented the character of work which needed co-operation from the designer in planning production through the foundry.

One example cited was the production of a rolling mill housing* measuring 16 ft. × 8 ft. × 34 ft., weighing 168 tons in the rough casting and finishing in the range of 134-178 tons. In addition to the problems mentioned above, the project in this case had been too large for the available melting equipment and the job had had to be made in two pieces which had subsequently been welded into a single unit. The two pieces which were welded had been carefully mapped, machined and fitted to provide

* Similar to the British Roll Housing made by the English Steel Castings Corporation and described in FOUNDRY TRADE JOURNAL, August 29, 1957.

American Engineers discuss Foundry Subjects

a joint into which 3 tons of thermite alloy containing iron, nickel, chromium, molybdenum and aluminium had been poured from an assembly of four large crucibles in a matter of 30 seconds. The extremely short pouring time was preceded by a 28-hour preheating period in the course of which the castings in the weld area were brought up to a temperature of 972 deg. C. The results were eminently successful and the joint after machining was undetectable in a visual inspection. The talk was further illustrated by a motion picture record of the production of castings of this type.

Process Controls for Making Turbine Castings

By R. D. Ahles

The Author pointed out that considerable progress had been made in the improvement of castings for elevated temperature service over the past five years and that turbine castings should now be made to perform successfully at 593 deg. C. for at least 25 years. Temperature, pressure and efficiency requirements over the past 20 years had progressively increased.

Date.	Working temperature, deg. C.	Pressure, tons per sq. in.	Efficiency, per cent.
1930	426	0.56	25–38
1956	593	1.07	44

The objective in the foundry had been centred upon improving the quality of castings and reducing the spread in their mechanical properties. Large castings weighing between 9 and 18 tons were involved. The specifications and the range of properties governing their control were given in the following table.

Composition.	Tensile, tons per sq. in.	Yield, tons per sq. in.	Per cent. elongation.	R.A.
C Mo Cr V 0.15 1.0 1.0 0.25	42–4	27	15	45
Range in 1952	38–54	27–52.5	—	—
Range in 1956	49–58	38–49	—	—

Castings up to ten inches in thickness had been judged by tests upon bars 4 in. thick. The objective had been to stabilize the chemical and mechanical properties, including the control of the normalizing and tempering of castings to produce a 70 per cent. ferrite structure.

Impurities such as sulphur and phosphorus have been reduced to extremely low levels.

	per cent.	per cent.
1952	0.022	0.023
1956	0.010	0.012

The nitrogen content had been lowered from 0.101-0.012 to 0.006-0.007 and the hydrogen content reduced to 3 parts per million from 6 parts per million. Using a tensile strength of 44.6 tons per sq. in. as a standard, the reduction of area specified at 45 per cent. minimum had not fallen under a 50 per cent. minimum for three years and, at the present time, usually ran in the 60-65 per cent. range. Production followed a pre-plan operating procedure. Defects had been reduced 80 per cent. by progressively correcting details. This procedure since 1954 had produced 60 per cent. fewer defects and had resulted in castings that were correspondingly more reliable.

In discussion the point was raised that basic electric-furnace melting practice was employed with the melt going in at 0.25 carbon which was oxidized and with oxygen lanced to 0.15 carbon. Heat-treatment usually was applied by fast cooling after heating to 1040-1100 deg. C. and tempering 60-80 hours at 690 deg. C. Test-bars were attached to castings and checked for properties after the entire cycle of operations had been completed. It was indicated that cast carbon steels in the petroleum industry were considered equal to wrought steels for the same chemical composition and mechanical property specifications.

Weld Fabricated and Repaired Steel Castings for Nuclear Service

By Sidney Low

The first phase of research was devoted to running short-time elevated temperature tensile and smooth-bar creep-rupture tests on castings containing a weld. Test-bars were machined with the weld at the centre of the gauge length and duplicate tests were conducted on the unwelded materials. The second phase was devoted to running thermal shock tests on cast/weld fabricated test bottles containing simulated weld repairs.

Large cast cylinders and smaller castings for thermal-shock tests were poured from heats of austenitic stainless steel (American Society for Testing Materials A351-52T, Grade CF8—0.06 C, 20 Cr, 9.50 Ni, tensile strength 32 tons per sq. in., yield point 17 tons per sq. in., elongation 58 per cent., reduction of area 62 per cent.) and carbon steel (ASTM A216-53T, Grade WCB—0.07 C, 0.57 Mn, 0.45 Si, 0.12 Cr, tensile strength 31.5, yield point 18.8 tons per sq. in., elongation 28 per cent., reduction of area 62 per cent.).

Short-time elevated-temperature tensile tests and smooth-bar creep-rupture tests were conducted on both welded and unwelded test-bars. No significant differences in the properties of welded and unwelded test-bars were found in the short-time tensile tests for either the austenitic stainless or carbon steels.

Creep-rupture test results for cast austenitic stainless steel, welded and unwelded, followed the same straight line while creep-rupture test results for cast carbon steel, welded and unwelded, showed that the welded test-bars were slightly stronger at the lower-strain rates.

A thermal-shock test was also run on a test-bottle designed for this purpose which contained simulated weld defects and a weld joint. The bottle was 12 in. long with 6-in. O.D. and 4-in. I.D., employing a ¼-in. wall thickened to 1¼-in. wall for a cavity length of 8 in. The walls were cut through

radially by a 20 deg. V notch, around the entire circumference, and then joined by welding. Thermal-shock tests were run on a weld-fabricated test-bottle designed to produce a large range of elastic stresses across both unwelded and simulated weld-repaired sections. The range of computed hoop stresses was 1.38 to 6.4 tons per sq. in. at the test-pressure of 2,500-lb. per sq. in. Simulated weld repairs were made on both the inside and outside walls of one-half of the test-bottle. The thermal-shock test castings were inspected radiographically and by means of fluorescent penetrant-oil/powder and found to comply with ASTM E71-52, Class I.

A weld-fabricated thermal-shock test bottle was heated to a temperature of 315 deg. C. and pressurized with argon gas to 2,500-lb. per sq. in. There was no evidence that the austenitic stainless-steel test-bottle was affected in any way by the 500 cycles of the thermal shock of chosen severity.

Tests showed that there was no inherent plane of weakness associated with weld repairs in castings and properly weld-repaired castings fully merited the same rating as a sound, unwelded casting. The author concluded by saying the tests and data should encourage nuclear-power plant designers to investigate the many advantages inherent in monolithic structures weld-fabricated from cast components.

Photoelastic Studies of Joining Sections in Steel Castings and Weldments

This presentation, by Mr. Henry Phillips of Adirondack Foundries & Steel Inc., consisted of a motion picture sponsored by the Steel Founders Society which demonstrated zones of high stress in various casting-plus-welded shapes by means of the brittle lacquer and the polarized light methods. The illustrations were instructively presented. The principal criticism from designers was that these methods merely located points of high stress or conversely of potential weakness without establishing the magnitude of these stresses.

American Engineers' AGM

The 1957 annual general meeting of the American Society of Mechanical Engineers which was held December 1 to 6 in New York comprised more than 140 technical sessions, at which a wide range of material was presented. Among papers of direct interest to foundrymen was "Properties of Cast Iron at Elevated Temperatures—A Progress Report" which was given during the "Effect of Temperature on Metals" sessions. The meeting also included a symposium on the welding of non-ferrous materials (particularly tubes).

The "Hydraulic" sessions included a symposium on "The Effect of Velocity on Cavitation Damage" which was held on December 2 and occupied the whole of that day. Also of interest was the paper "Machinability of High-strength Cast Irons" which was presented, on December 2, during the "Metal Processing" sessions.

THE Federation of Light Metal Smelters announces that its members' average selling prices for October, calculated to the nearest 10s., were:—LM1, £153 10s. per ton; LM2, £157; LM4, £180 10s.; LM6, £203.

News from Africa

Central African Federation

Southern Rhodesia may well be pleased at the prospect of a steelworks being established within its borders, and Que Que seems to be a likely centre of this activity. Sir John Duncanson, who is a director of Lancashire Steel Corporation, stated at Cape Town recently that a total of £8,000,000 would be invested in the steelworks which would be started at Que Que. He also said that the Lancashire Steel Corporation would itself open a £500,000 wire factory in 1958 in Que Que.

The Anglo-American Corporation of South Africa, the British South Africa Company, Tanganyika Concessions, and Stewarts and Lloyds have invested in the larger enterprise. The sponsors of the projected steelworks have already given orders to contractors for equipment and building materials. These orders amount to more than £4,000,000. The steelworks itself, it is forecast, will produce 200,000 tons of steel a year, and the hope is entertained that this figure will eventually be increased to 250,000 tons annually.

Steps in the £8,000,000 development programme of the Rhodesian Iron and Steel Company have been taken, and tenders for plant and equipment have been accepted. The company, a private one, bought the assets of the Rhodesian Iron and Steel Commission when it was de-nationalized. A condition of the take-over involves a programme of development envisaging the completion within four to five years of a unit, including coking ovens, capable of providing some 150,000 tons of steel a year and between 500 and 600 tons of pig-iron each week. The purchase price was just over £4,000,000.

Engineers at Kariba have constructed a concrete roof in preparation for a cave in a hillside. The roof is for the underground power house which will be 470-ft. long and 170-ft. wide, and it will probably be next April before the constructive work is finished. The power house will be 280 ft. below the level of Kariba Lake.

A £212,000 hydro-electric scheme is to be constructed on the Luombe River at Chishimba Falls, to serve the Kasama district of Northern Rhodesia with electric power.

The value of all minerals produced in Southern Rhodesia during the first seven months of this year was nearly £1,000,000 higher than that for the corresponding period of last year.

French Equatorial Africa

In French Equatorial Africa a big scheme has been planned to produce manganese. The deposits of manganese ore to be opened up near Francheville in the heart of Gaboon are described as among the richest in the world. More than 100,000,000 tons of ore are in sight and it is planned to produce 500,000 tons a year (worth about £8,000,000), but the first problem is to get the ore out of the mountains near the Equator, to the sea. A Franco-American company, Compagnie Miniere de l'Ogooue, in which U.S. Steel Corporation has a 49 per cent. interest, has agreed with the French authorities to construct a cableway, more than 40 miles long, across the mountains and a railway 160 miles long to link the southern end of this cableway with the Brazzaville-Pointe Noire railway line near Dolisie. Though construction work on communications has begun, the company does not expect to start exporting manganese from Pointe Noire harbour before 1960 or 1961.

Equipment & Supplies

Induced-spray Dust-collector

After an exhaustive study of desirable operating characteristics, with particular reference to low maintenance costs, Dallow Lambert & Company, Limited, of Thurmaston, Leicester, have produced a new range of self-induced spray-type wet dedusters, series MG, which are now available in sizes ranging from 2,000 to 48,000 cub. ft. per min. capacity. The deduster device collects fine particles by using abrupt changes in direction of the dust-laden gas to centrifuge particles on to irrigated surfaces where they are retained, and the kinetic energy of the gas is employed to create an intense spray zone where impingement of the very fine particles upon water droplets takes place. Fig. 1 shows these actions diagramatically. The dust-laden gas is brought down two vertical headers on to the main water surface where the two streams are deflected through a right-angle to a zone where violent collision occurs. The combined gas streams are then entrained, through a turn of very small radius upwards into the inner chamber, carrying with them a considerable volume of water. The intermixed water and gas

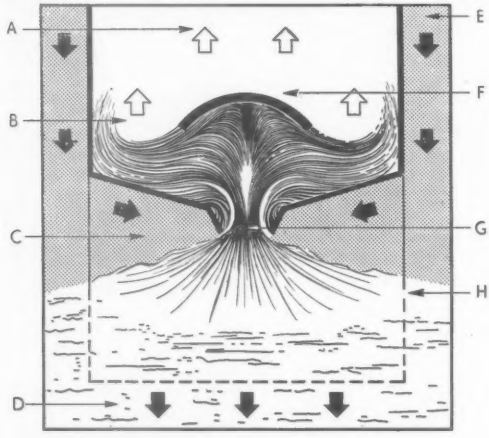


FIG. 1.—*Diagrammatic representation of the operating principles of Dallow Lambert's wet deduster.*

A—cleaned gas to spray eliminators; B—intense spray curtain; C—primary separation; D—water return *via* lute; E—incoming contaminated gas; F—central deflector plate; G—impact zone for principal separation, and H—lute.

impinges on a central plate which deflects the water to the sides of the inner chamber, so causing the gas to pass through an intense spray curtain. The gas then separates from the bulk of the entrained water, the fine water drops retained in the gas stream being caught by spray eliminators, which ensure negligible water carry-over to the fan and exhaust stack. All water drawn into the inner chamber returns to the bottom tank through lutes spaced at regular intervals.

Because of the high degree of turbulence achieved, the inner chamber is self-cleaning and there is no significant sludge deposition in this part of the equipment. Collected dust settles to the bottom of the main tank where it can be removed in sludge or slurry form, manually or automatically. The water content of the unit is maintained at the correct setting by means of an overflow pipe and electronic controls. It is

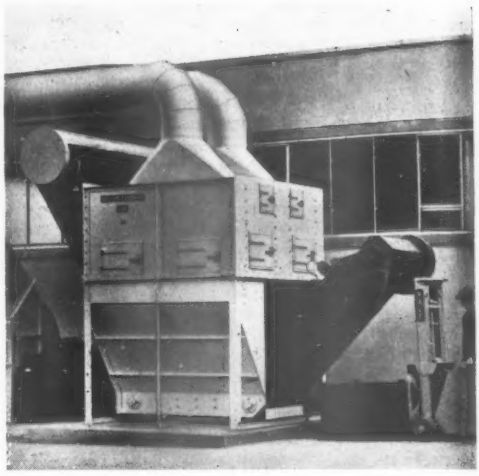


FIG. 2.—*Exterior view of a deduster unit.*

reported that the unit has been applied successfully in dust control and collection systems working in conjunction with foundry dressing, grinding, shot-blasting, sand preparation, casting and knocking-out processes. One battery of collectors at a large foundry handles 96,000 cub. ft. of dust-laden gas per minute. Fig. 2 shows a single unit of this type.

Air Control

To show some of the diverse features of industrial air control, A. Schrader's Son, of Erdington, Birmingham, have given a series of demonstration-talks in Birmingham, London and Manchester in the past few weeks. Four sessions were held in each area and technical personnel from many industries attended. A film was used to illustrate many air-operated machines and Mr. Phillip Hall, a Schrader engineer from the USA, talked on the latest practices in use there. Among the products recently added to the firm's range are new solenoid valves, spray guns and timed air-ejection sets—all manufactured in this country.

Aluminium/zinc/magnesium Alloy

In Information Sheet No. 60, Foundry Services, Limited, detail the properties of "Frontier 40E" alloy—an aluminium/zinc/magnesium casting alloy. The percentage chemical composition of the alloy reads: Zn. 4.8 to 5.7; Mg. 0.5 to 0.7; Cr. 0.4 to 0.6; Ti. 0.15 to 0.25; Fe 0.5 max; Si 0.25 max; Cu 0.10 max; Mn 0.10 max.; Pb 0.05 max., and Sn 0.05 max., with the balance Al. Average tests show 16 tons per sq. in. maximum stress; yield strength 13 tons per sq. in. associated with 7 per cent. elongation and a Brinell hardness ranging from 75 to 87. The British Patent rights for this alloy are held by the Frontier Bronze Corporation, Niagara Falls, USA, but exclusive rights to the manufacture and use of this alloy for Great Britain, Europe and the Commonwealth (excluding Canada) have been acquired by Daralum Castings, Limited, Darlington. A list of sub-licensed ingot makers is available from the Darlington company and Foundry Services, Limited.

Beating the Boredom

*Presidential address by R. E. Berry**

[ABRIDGED]

Recently, a very large firm of automobile manufacturers prepared a film about their foundry and machine-shops, one of the obvious purposes of which was to "star" the men who "press the buttons," endowing them with high skill and sense of responsibility. In what follows, Mr. Berry puts forward his ideas of how to tackle the boredom inherent in button-pressing operations—a very real problem in this age of rapidly increasing tempo of automatic working.

Founders should not overlook what is happening to labour as a result of the increasing use of science, mechanization and, perhaps, even automation in factory production lines, so what is intended in this address is to stand aside for a moment from this increasing scientific tempo of greater efficiency and production, and consider what effect it is having on the man on the shop floor.

Founding as an Art

First, one might recall work and life, and their relation to each other, as they were in days gone by. Before the industrial revolution, man's work consisted mostly of hard manual labour which provided little more than the bare needs of subsistence. In such industries as there were, most men were craftsmen (belonging to their various guilds) and they saw their jobs through from start to finish. In the foundries, whether bronze or iron, conditions were often appalling, but there were compensations which made the work tolerable. Founding was an art, not possible of achievement by fools and weaklings, and a good founder could obtain the full satisfaction of living from doing a job well, and from the sheer manliness of his hard toil. His work was integrated with his life just as was—and still is, for the most part—that of the farmer, and though he might grumble about his pay and conditions he had great pride in his craft.

Industrial Revolution

With the advent of steam power and the coming of the industrial revolution, as it is called, the craftsman's methods of working in the foundry industry remained largely unchanged for nearly a century, but the conditions of living and working slowly deteriorated. This change arose from the demands for greater output, the grouping of men into larger working and living units, the decline of the power of the guilds, and the often unstable economic conditions of the times. The hard toil, the over-crowded living-quarters and the periods of poverty, began to lessen the joys of craftsmanship but not obliterate them completely. Though none would wish to see these times back, they were often not as bad as they have been painted, and a foundryman was still a complete craftsman who could have the satisfaction of doing a job well and of seeing the finished product of his labour. He could not have been bored and his work was still an integral part of his mode of living. He was not yet a mere lever-pusher or a human automaton repeating indefinitely a set group of motions which could not be mechanized.

Note the ingredients which, so far, had made foundrywork, and other types of work, not only tolerable but interesting:—Craftsmanship, with the emphasis on good work rather than on maximum output; a tempo of working which allowed good work to be produced; and a degree of hard labour combined with skill and "knack," which added an element of physical satisfaction to the job. However, these conditions were to change; in the foundry the change is still going on, and even gathering momentum.

Demands of Mass Production

Mass-production techniques in engineering were first introduced by Henry Ford in the early years of the present century and it was not long before he applied the same techniques to his foundry; by 1920, he was producing over one million cars annually. He set the pattern for future development everywhere and the methods he used spread rapidly. This change was inevitable, because it was only by such a revolution that the insatiable demands of the modern way of life, both in war and peace, could be satisfied. Thus, jobs were broken down to their elements; all operations which could be mechanized were mechanized; and skilled and unskilled labour was set to perform repetitive, boring tasks. Output was the only thing that mattered.

So one comes to the present, the "machine age" rapidly changing to the "electronic age," where output is still generally the thing which matters most. It is an age in which few men on the shop floor are craftsmen and vast number of unskilled and semi-skilled men perform a small series of repetitive actions day-in, day-out, "come pay-day." Men have lost nearly all their earlier waywardness as regards when or how they do their work, and have all become wedded to the machine, to piecework and to the clock. The factory and the home are now entirely separate and distinct and the job is rarely a part of the way of living, it is merely a way of earning leisure to live away from the job.

The Result is Boredom

The result of these conditions is boredom. In fact, to work in a factory is now so boring for the

* Mr. Berry is this session's president of the East Anglian section of the Institute of British Foundrymen.

Beating the Boredom

vast majority of working men, that in the most materially advanced community in the world today, America, no effort is being spared to reduce the working week. In 10 years time, the Americans hope to reduce it to 32 hours. It has even been stated recently, in a journal devoted entirely to management, that as automation develops, men who are minding automatic plant will have to be paid "loneliness and boredom" money as a special incentive to perform tasks which involve doing precisely nothing.

This aspect of the working life, boredom, requires more consideration than at present it appears to be receiving, and may be at the root of a lot of our industrial labour problems. The unions' cry for a shorter working week and more pay is a cry for a shortening of the period of boredom and for more money to enjoy the increased leisure hours. Manufacturers can only meet these demands by introducing more mechanization and, nowadays, automation, to increase the output in the shorter time available. The result, except for a growing body of scientists and technicians, will be more boredom for the average working man, as foreshadowed in the journal referred to earlier.

Remedies

What can be done to prevent, counteract or alleviate this boredom which is so soul-destroying and which, the writer believes, is having such an insidious effect on industrial relations? The problem is universal in industry as a whole, but the foundry industry is fortunate in that whilst this problem of boredom applies in the mechanized, repetition foundries, it is only felt to a slight extent in the jobbing foundries. These will always be with us and will remain the home of the full-trained foundry craftsman. Therefore, some of the suggestions which follow may not apply to all foundries and may have to be modified in the light of conditions already prevailing:

The best use should be made of the existing skill and physical abilities of labour. Thus, jobs should not be simplified, instrumentated, or otherwise controlled without giving more outlets for the skilled worker to use his knowledge and ability to better advantage. The "men on the floor" should be allowed and trained to use instruments (pyrometers, etc.); these should not be a sole prerogative of the laboratory staff. More responsibility should be given to labour as the physical drudgery is reduced.

Where mechanization or automation is planned, it should first take over the jobs of lower skill. Where mechanization is well advanced then the operators should be trained to understand the broad principles of the machines they are using. Pride should be created in the handling of complex equipment. Like driving a motor car, the best results are always obtained from a machine when the underlying principles are understood, and this in itself creates interest in the job.

Sense of Participation

Satisfaction in the work being done should be stimulated by giving the men a sense of participation in the firm. This means that they must be taken into the confidence of the management as fully as possible, so that new interest is created in the functioning of a department or of the works as a whole. There must be more employee/management joint councils. Production, scrap and bonus figures should be published at frequent intervals and should be readily understandable. The introduction of new technical changes should be accompanied, in good time, by consultation with the workers' representatives. Foremen, particularly, should be well briefed as to all new developments. Pay rates and forms of payment should be carefully studied so as to assist in job satisfaction and not become sources of irritation.

If mechanization (or automation) is, or becomes, so far advanced that the ordinary workman's job requires little or no skill, then pride of workmanship must be transferred to pride in cleanliness and conditions of working. All efforts should be made to so improve conditions that the men have as much pride in the cleanliness, brightness and atmosphere of their workplace as they should have in their homes.

Beware Monopolies

Finally, there is one broad aspect of this subject which the writer is sure has a bearing on the lack of satisfaction a man may have in his job—and lack of satisfaction breeds disinterestedness and boredom from which other ills follow. It is believed that there is an economic size of factory in each field of manufacture. On each side of this economic size there is a wide range in which a company can function economically (though perhaps not with the maximum of efficiency) and can give satisfaction to all its employees. But companies which become exceedingly large or too-wide-ranging in their activities, as a result of amalgamations, take-over bids, etc., tend to lose their "soul." Monopolies in one class of manufacture also fall into this category. Eventually, such companies have a tendency to bureaucratic control; and imagination, flexibility and enterprise are suffocated There is no real job-satisfaction under such conditions, and society should endeavour to prevent this type of growth whether it occurs as a result of government nationalization or financial manipulation.

Canadian Subsidiary for British Tractor Firm

British tractor manufacturers, Vickers-Armstrongs (Tractors), Limited, has now a Canadian subsidiary, Vickers-Armstrongs (Tractors) Canada, Limited. The new company, which has its registered office in Montreal, already has a depot in Vancouver and is to open a second depot in Toronto shortly. The Vancouver depot will service provinces west of Ontario.

The first directors are: Mr. W. J. R. Cupples (commercial director of the parent company); Mr. L. J-B. Forbes; Mr. J. Mossop, and Mr. A. P. Wickens (managing director of the parent company). The secretary of the company is Mr. J. M. Anderson.

BSCRA Annual Conference

For three successive years almost 90 per cent. of the members have been represented at the annual conferences of the British Steel Castings Research Association. This year's conference, held at York from November 21 to 22, was on the subject of "Cleaning, Inspection and Welding of Steel Castings."

In his opening address Mr. C. H. Kain, chairman of the Association, said the annual wage bill for the finishing processes in British steel foundries exceeded £5,000,000. He was quite sure that each delegate could gain from the conference information which, if applied, would more than offset the cost of contributions to the Association. Referring to the sessions of the conference dealing with casting inspection, Mr. Kain said the conditions of service for steel castings were becoming continuously more stringent and more varied, and standards of inspection must march in step with this trend. Just as the strength of a chain was the strength of the weakest link so was the reputation established by 10,000 good castings shattered by the failure of one, no matter who was the supplier. This was a sphere where co-operation between steelfounders could do nothing but good in enhancing the prestige of steel castings amongst users and where the Association would help industry to establish and maintain uniformly high standards of practice. One step in this direction had already been taken by the Association by the publication of a code of practice on magnetic-particle inspection and it might be that with the co-operation of members, further codes could be prepared in relation to other techniques.

Mr. Kain took the opportuniy to announce the Association's intention of holding, next year, courses for the personnel of member companies to consider various aspects of technical control in steelfoundry processes.

Programme Details

At the first two sessions, on the cleaning and fettling of steel castings, papers were presented under the chairmanship of Mr. M. C. Lloyd (F. H. Lloyd & Company, Limited) and Mr. R. F. Horton (Osborn Foundry & Engineering Company, Limited) as follow: "Cleaning and Finishing of Heavy Steel Castings" by H. C. J. Corke (English Steel Castings Corporation Limited); "Cleaning and Fettling of Medium and Small Steel Castings" by D. Brown (Bonnington Castings Limited); "Acid Pickling of Steel Castings" by Q. C. McMillan, A.R.C.S.T., F.I.M. (Clyde Alloy Steel Company, Limited); and "Recent Developments in the Cleaning and Fettling of Steel Castings" by C. M. Stoch, DIPL.ING., F.I.M. (BSCRA).

Mr. Corke's paper described the sequence of operations employed in the finishing of large steel castings up to 185 tons in weight and mentioned the successful application of such processes as powder-washing and the air/carbon-arc torch. Mr. Brown gave an analysis of handling operations in fettling shops processing small steel castings and detailed comparative costs for alternative shot-blasting equipment and materials as well as time and cost comparisons for the air/carbon-arc torch and the pneumatic chisel. Mr. McMillan's paper represented a complete account of the theory and practice of acid pickling as applied to the cleaning and inspection of steel castings for high-duty application. Amongst recent developments referred to by Mr. Stoch were chemical methods (other than acid pickling) of cleaning steel castings and a process of "electro fettling" briefly described in recent Russian literature.

The third session of the conference was presided over by Brigadier A. Levesley deputizing for Mr. G. T. Harris, of William Jessop & Son, Limited, who was prevented by illness from attending. The three papers presented for discussion related to inspection techniques: "Place of Radiography in the Steel Foundry" by T. Bailey, B.SC., and S. H. Juby, A.S.I.R. (K. & L. Steelfounders & Engineers, Limited); "Magnetic Particle Testing of Steel Castings" by R. J. Hart (Lake & Elliot, Limited), and "Ultrasonic and Other Inspection Procedures" by J. F. Hinsley, F.I.M. (Edgar Allen & Company, Limited).

Apart from the use of X- and gamma-radiography for final inspection purposes, Mr. Bailey and Mr. Juby discussed their application as an aid to the methods section in establishing production techniques. Mr. Hart's paper provided a practical account of the varied application of magnetic-particle inspection and laid some emphasis on the extended scope of application following the introduction of magnetic powders as compared with magnetic inks. The major portion of Mr. Hinsley's paper described the theory and potential practical application of ultrasonic flaw-detection, but he also described a number of techniques that are available for special applications including, for example: logarithmic-decrement measurement; radiological scanning; image intensification, and eddy-current testing devices.

Welding

Mr. W. S. Scott, Darlington Forge, Limited, took the chair at the final session of the conference which was devoted to the subject of welding. In his opening remarks he said that welding was now regarded both by steelfounders and their customers as a legitimate manufacturing operation which, in many cases, enabled an improved and sometimes cheaper product to be supplied.

The two papers presented at this session were: "The Training of Welders" by G. H. E. Bottrill (English Steel Castings Corporation, Limited), and "Welding Techniques" by M. D. Jackson, B.MET., A.I.M., A.INST.W. (Hadfields, Limited).

A novel feature of the conference this year was an after-dinner session presided over by the chairman of the Association's Research Committee, Dr. E. Gregory, of Edgar Allen & Company, Limited, at which a lecture was delivered by Dr. A. H. Sully, the director of research, who brought into relief some of the research projects in progress at the Association's laboratories.

Iron Castings Production

Production of iron castings in the third quarter this year was 2 per cent. lower than in the third quarter of 1956, but output for the automobile industry was at a record third-quarter level. The Iron and Steel Board states that production in the first three quarters of 1957, with comparable 1956 totals in parentheses, were:—961,990 (1,039,670) tons; 944,460 (1,022,040) tons; 846,600 (863,950) tons.

Although the drop compared with last year was 17,350 tons, the seasonal decline between the June and September quarters was less this year than last—10.6 per cent., compared with 15.4 per cent. The principal drop in the third quarter was recorded in the east Midlands, where 30,210 tons less was produced, whereas in the adjoining district of the west Midlands there was the largest increase—nearly 12,000 tons.

Comparing the 1956 and 1957 figures for the third-quarter tonnages, the automobile industry (including tractors), at 125,500 tons, showed a rise of 32.9 per cent. Ingot moulds mainly for the steel industry, at 105,500 tons, went up by 9 per cent. and railway equipment, at 76,900 tons, by 6.4 per cent. Pressure pipes (mainly gas and water) and fittings section, at 113,600 tons, fell by 26.2 per cent., engineering, including machine tools, textile machinery, electrical, shipbuilding, etc., at 300,700 tons, by 6.2 per cent., and building and domestic section, 124,400 tons, by 1.2 per cent. The fall in total production is mainly attributable to difficult trading conditions in the pressure-pipe section.

Consumption of pig-iron (including refined iron) in the third quarter dropped by 6 per cent. (524,600 tons to 493,100 tons) compared with 1956, but scrap consumption (about half of which is foundry circulating scrap) rose by 4.6 per cent. (685,000 tons to 716,500 tons). The number employed in the ironfounding industry at September 28 was 137,900, an increase of 100 on the total at the end of the first quarter of 1957.

Aluminium/Tin Bearing Alloy

The bringing into production of a new type of bearing alloy is announced jointly by the Tin Research Institute and the Glacier Metal Company, Limited, who have been working together for some years on its practical development. The new bearing alloy contains about 20 per cent. of tin, the remainder being aluminium hardened with from 1 to 3 per cent. of copper. The tin constituent has a structure which is reticular within the continuous aluminium matrix, that is to say, the tin has a structure which is itself continuous without disturbing the continuity of the aluminium. Should metal to metal contact occur between a shaft and a bearing with this reticular structure, there is an immediate supply of tin available at the surface to provide a thin soft layer of tin over the aluminium and thus inhibit surface breakdown.

The alloy, therefore, combines the strength of a continuous aluminium phase with the tin-availability of a comparatively heavy and continuous tin structure. When supplied in the form of steel-backed bearings, it provides a better balance between the opposing demands of high fatigue strength and low rates of wear than any other known plain bearing. Furthermore, unlike copper/lead bearings, it needs no lead-based overlay plating to keep shaft wear in check.

ROTHERHAM HEALTH COMMITTEE has asked the education committee to consider the use of smokeless fuel in school-heating plants.

Teaching Foundry Practice in Middlesex

An article in the *Sunday Observer* made it abundantly clear that in Middlesex stress was being placed on technology in both the grammar and modern schools. The writer recently had the privilege of inspecting two schools coming within the jurisdiction of the Middlesex County Council Education Department. Here, technology, in practical terms, meant the provision of metal-melting facilities, a well-equipped machine-shop and a woodworking department. Permeating the whole set-up is the underlying principle that a neophyte engineer or technician should be familiar with every process to be performed in the construction of a machine or its components. Thus, the lads—and occasionally a girl—make simple patterns, make moulds, castings, and either watch them cast or themselves cast them up, in aluminium or brass. The castings are afterwards cleaned, machined and built up into miniature tools or engines. Obviously the students do not make all the castings they use but at least they do know how they are made. Many are bought (or begged) from interested foundries and built into models of plant and machinery and, actually, one of these boys gained a premier award at the Model Engineering Exhibition, recently. It was obvious during the visit that the boys were fascinated by the founding craft. Like most developments of this character, the attraction of founding in this scheme is due to the enthusiasm of just a few people. Outstanding has been the work of Mr. A. Talbot, foundry manager at Western Foundries, Southall, who has devoted a series of Saturday mornings instructing the teachers in the making of moulds. He has collaborated very closely with Mr. Care, a principal officer in the directorate of the County Education Department, to whom the writer is indebted for the privilege of seeing the system in operation at what must surely be two of the best designed and ambitiously-equipped schools in the country.

Cost of New Plant

Many people failed to realize how significant plant had become in modern industry, said Sir David Anderson, director of the Royal College of Science & Technology at the annual dinner of the Glasgow branch of the Incorporated Plant Engineers. Proposing the toast of "The Institution," he quoted figures which showed that for every person employed there was represented in fixed assets in buildings, plant, and equipment, the following totals:— Shipbuilding, £1,000; mechanical engineering, foundries, tobacco, £1,500; rubber, £1,750; non-ferrous metals, £2,500; cement manufacture, £3,000; iron and steel, £3,500; textiles, paper manufacture, £4,500; grain milling, £5,000; and oil-refining, £13,000. To maintain buildings, plant and equipment of that value per person employed showed to what an extent plant and equipment had become the dominating feature in the modern industrial scene, and from the figures quoted it was clear that a great responsibility rested on the shoulders of the plant engineer, in that the potential loss was high if anything went wrong with the plant.

COPIES of the seventh edition of the "Members Handbook" of the Gauge and Tool Makers' Association, which includes a comprehensive buyers' guide index to the products of the 350 member-companies, are now available on application to the Association, Standbrook House, Old Bond Street, London, W.1.

Company News

ARMSTRONG WHITWORTH (METAL INDUSTRIES), LIMITED—An interim dividend of 2½ per cent. is announced by the company in respect of 1957. Last year there was a single payment of 10 per cent. on the £625,000 ordinary.

ROTARY HOES, LIMITED, agricultural machinery manufacturers, of Horndon (Essex)—The company is paying an interim dividend of 5 (nil) per cent. for 1957. With the first and final for 1956 of 7½ per cent. was an extra 2½ per cent. in respect of taxes recovered.

CONSETT IRON COMPANY, LIMITED—The final dividend is being raised from 4½ per cent. to 5¼ per cent., to make 8¾ per cent. for the year ended September 28, 1957, compared with 7½ per cent. After depreciation and debenture interest, the group profit of £3,924,521 compares with £3,260,646. The net balance is £1,195,740 (£1,007,574).

DERITEND STAMPING COMPANY, LIMITED—An interim dividend of 7½ per cent. is being paid on the £594,655 capital as increased by the one-for-two scrip issue, in respect of the year to February 28, 1958. For the previous year an interim of 5 per cent. on the former capital was followed by a final of 12½ per cent. on the enlarged capital.

SPEEDWELL GEAR CASE COMPANY, LIMITED—The company is making efforts to obtain more favourable prices from the Iron and Steel Board for steel supplies. Trading profit for the year to July 31, 1957, was £71,616 (£46,212). After depreciation and tax, etc., net profit was £19,994 (£13,943). The ordinary dividend is 15 (10) per cent.

ENGLISH ELECTRIC COMPANY, LIMITED—The directors announce that there will not be a drawing this year of the 4 per cent. debenture stock (1965-85) or 4½ per cent. debenture stock (1972-1977) because, in accordance with the terms of the trust deed, the company has made purchases in the market up to the amount set aside for the sinking fund. Taking these purchases, totalling £68,261 and £174,570, respectively, into consideration, the outstanding 4 per cent. debenture stock amounts to £2,590,085 and the 4½ per cent. debenture stock to £4,680,763.

TRIPLEX FOUNDRY, LIMITED—The chairman, Mr. W. H. L. Harrison, states that fuel appliances, the manufacture of which was running at a loss, now form only a small part of business. It is added that the iron-foundry has reached a stage where a return on the capital invested can be expected. Group profits in the half-year ended September 30, at £8,000, compared with a loss of £72,000 in the year ended March 31, last. In addition the company realized a further surplus of £29,000 on the disposal of fixed assets. The half-year's result includes pre-acquisition profits of £25,000 by the two subsidiaries acquired, Henry Harrison & Sons, Limited, Willenhall (Staffs), and Vowles Aluminium Foundry Company, Limited, West Bromwich (Staffs). These have been dealt with as capital, leaving the net trading result for the half-year at a loss of £17,000.

JOHN DALE, LIMITED—Mr. P. J. A. Lachelin has been appointed a director and deputy chairman.

CARBORUNDUM COMPANY, LIMITED—Mr. G. R. McKenzie and Mr. G. J. Zimmerman have been appointed directors and Mr. W. H. Wendel has replaced Mr. F. J. Tone, Jnr., on the board. Mr. J. A. Williamson, managing director, has been elected chairman and Mr. W. B. Cleverly and Mr. G. R. McKenzie have been appointed managing director and deputy managing director, respectively.

Canadians Admire Efficiency of British Industry

British industry had received a "shot in the arm" as a result of the Canadian trade mission's visit, Sir William Rootes, chairman of the Dollar Exports Council, told a Press conference in Glasgow on December 3. Over 1,200 requests for interviews had been received and it was proposed to hold conferences at the Dollar Export Council's offices in London on December 12, 13, and 16.

Mr. James S. Duncan, deputy leader of the mission, said that results had far exceeded expectations. The efficiency of British industry and its labour was as high as anywhere in the world. He thought the largest volume of imports to Canada would be in the iron and steel range; items such as road machinery and motor-cars were likely to make the most rapid progress.

Mr. George Drew, High Commissioner for Canada, thought it would be folly to ignore the great potential market which Canada offered for the future. Rich as it was in many mineral resources, they should consider the Canadian market, not only in the light of its population of 17,000,000 to-day, but the big increase that would take place in the next 25 years.

During the day the Canadians visited the works of the Motherwell Bridge & Engineering Company, Limited, and Babcock & Wilcox, Limited, and the Linthouse shipyard of Alexander Stephen & Sons, Limited. At the Renfrew works of Babcock & Wilcox, the largest in the world devoted to the manufacture of steam-raising plant, the party was received by the managing director, Sir Kenneth Hague.

The visitors were shown the final stages in the fabrication of the sections and domed-ends of the last of the 16 steam-raising units for Chapeltown atomic power station. Conventional boiler plant included a 106-ton fusion-welded steam drum for one of the four 860,000 lb. per hr. Babcock Radiant boilers for the CEA power station at Blyth (Northumberland).

Steel Import Duties

Under the Import Duties (Exemptions) (No. 6) Order, 1957, the import duties on blast-furnace ferro-manganese and on a wide range of iron and steel products are suspended until March 18, 1958. Under the Import Duties (Exemptions) (No. 10) and (No. 12) Orders, 1957, duties are suspended until September 18, 1958, on plate and on cold-reduced sheet of a value of under £90 a ton.

The Board of Trade states that, after consultation with the Iron and Steel Board about the supply position, the Government has decided to prolong until September 18, with some exceptions, the suspension of import duties in respect of those other iron and steel products where duty is now suspended. The exceptions, on which duty will be restored on March 19, are blast-furnace ferro-manganese and sheet (other than the cold-reduced sheet already mentioned and wide hot-rolled strip in coils).

A new Order—the Import Duties (Exemptions) (No. 16) Order, 1957 (SI 1957, No. 2045), has therefore been made and will come into operation on March 19, 1958. Copies of the Order may be obtained from the Stationery Office, price 3d. (by post 5d.).

Two 180-mva. 275/132 kv auto-transformers for installation at Skelton Grange have been ordered from the British Thomson-Houston Company, Limited, by the Yorkshire Division of the Central Electricity Authority.

Pig-iron and Steel Production

Statistical Summary of September Returns

The following particulars of pig-iron and steel produced in Great Britain are from statistics issued by the British Iron and Steel Federation. Table I summarizes activities during recent months. Table II gives production of steel ingots and castings in September and Table III, weekly average production of finished steel. Table IV gives the production of pig-iron and ferro-alloys in September, and furnaces in blast. (All figures are weekly averages in thousands of tons.)

TABLE I.—*Iron and Steel Price Index and General Summary of Pig-iron and Steel Production.*

Period.	B.o.T. Price Index, 1938 = 100.			Iron-ore output.	Imptd. ore used.	Coke to blast-furnaces.	Pig-iron, ferro-alloys prod.	Scrap used in steel prod.	Steel (incl. alloy).			
	I. & S.	Coal.	Basic materials excl. fuel [1]						Imports. [2]	Prod. ingots, castings.	Delivrs. finished steel.	Stocks. [3]
1955	276	399	529	311	244	246	240	213	29	381	305	1,247
1956	295	454	542	312	272	264	253	216	27	397	318	1,444
1957—June ..	317	498	540	322	302	274	275	222	14	419	317	1,483
July [4]	320	501	537	316	292	264	263	190	17	362	273	1,579
Aug. ..	341	502	535	299	313	267	272	190	13	373	270	1,673
Sept. ..	342	501	525	326	313	271	283	233	13	438	—	1,640

TABLE II.—*Weekly Average Production of Steel Ingots and Castings in September*, 1957

District.	Open-hearth.		Bessemer.	Electric.	All other.	Total.		Total ingots and castings.
	Acid.	Basic.				Ingots.	Castings.	
Derby, Leics., Notts., Northants and Essex ..	—	4.1	13.3 (basic)	2.4	0.1	18.5	1.4	19.9
Lancs. (excl. N.W. Coast), Denbigh, Flints. and Cheshire	1.7	34.5	—	2.7	0.4	37.7	1.6	39.3
Yorkshire (excl. N.E. Coast and Sheffield) ..								
Lincolnshire	—	46.1	—	—	0.1	46.0	0.2	46.2
North-East Coast	1.1	80.3	—	1.6	0.4	81.2	2.2	83.4
Scotland	2.7	49.9	—	2.7	0.3	53.3	2.3	55.6
Staffs., Shrops., Worcs. and Warwick	—	19.9	—	1.3	0.8	20.0	2.0	22.0
S. Wales and Monmouthshire	4.8	92.0	7.3 (basic)	1.1	0.2	104.7	0.7	105.4
Sheffield (incl. small quantity in Manchester) ..	10.6	35.4	—	12.6	0.5	56.9	2.2	59.1
North-West Coast	0.1	1.9	4.6 (acid)	0.6	0.1	7.2	0.1	7.3
Total	21.0	364.1	25.2	25.0	2.9	425.5	12.7	438.2
August, 1957	13.5	315.0	23.9	18.7	2.3	363.6	9.8	373.4
September, 1956	21.1	342.6	25.0	25.2	3.1	404.4	12.6	417.0

TABLE III.—*Production of New Non-alloy and Alloy Finished Steel.*

Product.	1955.	1956.	1956.	1957.	
			August [4]	July. [4]	August.
Non-alloy steel:					
Ingots, blooms, billets and slabs [5]	4.9	4.7	3.3	3.8	3.7
Heavy rails ..	9.4	9.7	6.7	10.1	7.5
Sleepers, etc. ..	2.0	1.8	0.9	1.6	1.1
Plates, 3 mm. and over	46.1	50.2	38.9	41.9	49.7
Other heavy prod.	47.8	50.3	35.4	40.8	45.9
Ferro-con. bars, etc.	7.0	7.8	5.9	8.0	7.9
Wire rods	22.2	22.9	17.8	16.1	22.1
Arches, etc. ..	9.6	10.1	6.8	7.8	10.4
Other light sections	36.8	41.4	28.8	31.5	29.1
Bright steel bars ..	7.8	8.0	5.3	6.5	5.3
Hot-rolled strip ..	24.1	24.5	14.8	20.7	15.7
Cold-rolled strip ..	8.1	7.5	4.5	6.4	5.2
Sheets, incl. coated:					
(i) Hot rolled ..	16.6	15.0	11.4	11.9	10.8
(ii) Cold reduced	26.1	24.8	18.5	26.9	28.0
Tin and terneplate	15.6	15.9	11.2	20.1	11.7
Blackplate ..	1.4	1.3	0.6	1.0	0.6
Steel tubes, pipes ..	22.9	26.2	20.0	23.7	20.8
Tube, pipe fittings	0.4	0.5	0.3	0.4	0.4
Tyres, wheels, axles	4.8	4.6	3.2	4.8	3.6
Forgings (excl. drop forgings) ..	2.5	3.0	2.0	2.7	2.6
Steel castings ..	4.2	4.5	3.3	3.9	4.0
Tool and magnet steel	0.3	0.3	0.2	0.3	0.2
Total	320.6	335.0	239.8	290.9	286.3
Alloy steel	15.8	17.3	10.7	15.9	13.7
Total deliveries from U.K. prod. [6] ..	336.4	352.3	250.5	306.8	300.0
Add: Imported finished steel ..	18.9	19.5	11.7	9.0	11.1
	355.3	371.8	262.2	315.8	311.1
Deduct: Intra-industry conversion [7] ..	50.9	55.2	35.9	44.2	41.8
Total new material ..	304.4	316.6	226.3	271.6	269.3

TABLE IV.—*Production of Pig-iron and Ferro-alloys during September*, 1957

District.	Fur. naces in blast.	Hema-tite.	Basic.	Foun-dry.	Forge.	Ferro-alloys.	Total.
Derby, Leics., Notts., Northants and Essex	24	—	27.1	20.4	0.4	—	47.9
Lancs. (excl. N.W. Coast), Denbigh, Flints. and Cheshire ..	6	—	21.4	—	—	0.9	22.3
Yorkshire (excl. N.E. Coast and Sheffield) ..	—	—	—	—	—	—	—
Lincolnshire ..	10	—	43.8	—	—	—	43.8
North-East Coast	20	4.5	54.2	—	—	1.0	59.7
Scotland	10	0.8	20.9	1.9	—	—	23.6
Staffs., Shrops., Worcs., and Warwick ..	7	—	10.5	1.6	—	—	12.1
S. Wales and Monmouthshire	11	4.9	46.5	—	—	—	51.4
Sheffield ..	1	—	2.2	—	—	—	2.2
North-West Coast	8	18.5	—	—	—	1.2	19.7
Total ..	97	28.7	226.6	23.9	0.4	3.1	282.7
August, 1957 ..	99	27.7	219.2	21.4	0.7	3.5	272.5
September, 1956 ..	99	30.7	190.9	26.6	1.1	3.2	252.5

[1] Used in non-food-manufacturing industry.
[2] Weekly average of calendar month.
[3] Stocks, mainly ingots and semi-finished, at the end of the years and months shown.
[4] Five weeks, all tables.
[5] Other than for conversion into any other form of finished steel listed.
[6] Includes finished steel produced in the U.K. from imported ingots and semi-finished steel.
[7] Material for conversion into other products also listed in this table

News in Brief

AN ORDER for a new flour-mill capable of milling some 130 tons of wheat every 24 hours has been placed with Thomas Robinson & Son, Limited, Rochdale, by Aftab Flour Mills of Karachi, Pakistan.

A CHANGE OF OFFICE ADDRESS is announced by Industrial Foundry Materials Limited. Larger premises have been taken at Midland Bank Chambers, Lye, near Stourbridge. But the stores and stores office will remain at Dudley Road, Lye, as at present.

FELLOWS & DARBY, LIMITED, patternmakers, of Slaney Street, Birmingham, announce that they have acquired the business of William King (Birmingham), Limited, also of Birmingham. This firm was founded in 1885 and is one of the oldest established firms of master patternmakers in the country. Both companies will continue to trade separately, under the management of Mr. Walter D. Hartley, who is well known in the foundry industry.

A GROUP of 28 students from the *Centre d'Etudes Industrielles*, the international management school at Geneva, began a two-week tour of the Midlands on December 2. The students, led by Mr. U. von Freyberg, the German director of industrial training at the Institute, are particularly interested in the steel, nonferrous, car, electrical and mining industries. A tour of the British Motor Corporation's works at Longbridge was made on December 3.

THREE HUNDRED WORKERS of the Ruston-Bucyrus excavator works at Lincoln were told at a meeting in Lincoln Drill Hall on November 30 by union officials that in the interests of everyone, it might be necessary for them to share their work. He said they wanted to group all the work available and, if necessary, would take work from some machines and put it out to others. It might mean a reduction of working hours for some in order to benefit others with less.

THE LOUGHBOROUGH BELL FOUNDRY of John Taylor & Company, Leicester, is to make a presentation bell to the order of the Loughborough-Epinal Twinning Organization at a gift to the town's French "twin town" of Epinal. The bell is to have the same dimensions as those of Loughborough Town Hall clock and it will be tuned to sound the same note. The inscription has yet to be settled and it is proposed to display the bell at Loughborough before it is officially handed over.

LAST WEEK, Mr. Frank Aitken, Irish Minister for External Affairs, outlined his Government's plans for the proposed Dundalk Engineering Works, the formation of which follows the closing of sections of railways in the North of Ireland, resulting in the cutting off from Dundalk Railway Works of practically all railway servicing work. He referred to the immense quantity of material imported into Ireland from foreign engineering works, and implied that the new venture presented an opportunity to reduce the considerable cost of these imports.

SWEDEN'S iron-ore output rose by 10 per cent. to nearly 10,300,000 tons in the first half of 1957 compared with the same period last year. Deliveries were up by 5 per cent. to about 9,000,000 tons. The remaining 1,300,000 tons were added to stocks. Exports were up by 4 per cent. in volume (15 per cent. in value). The iron and steel works report a 13 per cent. increase in pig-iron output and a 9 per cent. increase in ingot production. The output of commercial iron and steel was up by 10 per cent. Steel exports rose by 6 per cent. in volume (14 per cent. in value).

FURTHER orders received by Birlec, Limited, Erdington, Birmingham, for their recently-developed main-frequency coreless induction-melting furnace, include a repeat order for a 30 cwt. furnace rated at 450 kw. for melting iron for Miller and Company, Limited, at whose Edinburgh works one of the first of these units was installed last March. Also for iron melting, West Yorkshire Foundries, Limited, of Leeds, have ordered two 6-ton furnaces, rated at 1,100 kw., with a central sub-station to power both units. Furnaces ordered or installed now number well over 30 units.

BRADFORD'S NEW INSTITUTE OF TECHNOLOGY has received gifts in money, plant and materials amounting to £7,905, including £3,350 from the Wool Textile Research Council for apparatus and stores; £2,000 from Mr. H. Gregson, of the Worcester Textile Company, Inc., Rhode Island, USA, in the form of a Warner & Swasey pin drafter; £800 from Imperial Chemical Industries, Limited; £500 from Samuel Law & Sons, Limited, Cleckheaton; £300 each from J. T. Hardaker, Limited, Bradford, and the British Optical Association; and £250 from Shell Chemicals, Limited. Samuel Law & Sons, Limited, have also given £126 for repairs to worsted card.

COLTRATE LIMITED, New Broad Street House, 35, New Broad Street, London, E.C.2, announce the introduction of a new range of refractory protective coatings under the name of Coltrate R.P.C. The complete range of which (glazed types) covers the following temperature ranges:—Loglaze 827-804 deg. C. to 1,148 deg. C., Midglaze 995-982 deg. C. to 1,260 deg. C., Higlaze 1,221-1,204 deg. C. to 1,649 deg. C. A non-vitreous type is also available, and this covers the complete temperature range from 50 deg. F. to 1,926 deg. C.; and also a refractory mortar for bonding, patching and plugging, designed to be effective over the temperature range up to 1,649 deg. C.

A GIFT OF £21,000 from the United Steel Companies, Limited, and £15,217 from English Steel Corporation, Limited, were announced in Sheffield on November 27 as part of the £150,000 Sheffield Cathedral Enlargement Appeal Fund before the making of the £100,000 final appeal. Other gifts and promises include:— Thos. W. Ward, Limited, £9,999; Edgar Allen and Company, Limited, £6,086; Brown Bayleys Steel Works, Limited, £6,086; Hadfields, Limited, £6,086; Davy and United Engineering Company, Limited, £4,869; Arthur Lee and Sons, Limited, £3,652; Park Gate Iron and Steel Company, Limited, £2,500; Swift Levick and Sons, Limited, £2,434; Firth-Vickers Stainless Steels, Limited, £1,826; British Ropes, Limited, £1,498; Darwins, Limited, £1,050.

Sir FREDERICK PICKWORTH, Master Cutler, and chairman of the English Steel Corporation, Limited, Sheffield, presented the prizes at the firm's annual young people's prize-giving on November 29. Over 300 gained awards and cash prizes totalled £1,234. Sir Frederick emphasized the need of young people making the most of their opportunities. He said that of the firm's 780 workers under 21, only two-thirds were doing education in their own time, and he hoped the number would get nearer 100 per cent. Mr. H. Parkin, education and training officer, said in his report that recruiting to the firm had improved in recent years, but they could not afford to be complacent. A survey was being made of recruitment plans to meet the difficulties presented by a combination of circumstances in the next five or ten years, including the "bulge" in the number of school-leavers, the proposed abolition of National Service, and the expansion of the company's activities.

Personal

Airtech, Limited, Haddenham, Bucks, announce that Mr. P. J. LANGDON, has been appointed sales manager of the new engineering division.

Mr. J. H. KING has been appointed chairman of Austin & Pickersgill, Limited. He succeeds Mr. J. C. FLISHER, who has relinquished the chairmanship but remains as vice-chairman.

The David Brown Corporation, Limited, announces that Sir ROBERT BOOTHBY, M.P., has accepted an invitation to join the board. Sir Robert has been Unionist member for East Aberdeenshire since 1924.

Mr. A. J. SOMERS has retired after 36 years with Borax Consolidated, Limited, Carlisle Place, London, S.W.1; since February, 1946, he has been a member of the board of the parent company, now Borax (Holdings) Limited.

Mr. T. H. PHILLIPSON, works manager, Rose Bros., Limited, engineers, Gainsborough, and Mr. R. G. Radley, sales manager, both of whom have been associated with the firm for 40 years, have been appointed directors.

Mr. D. J. BELL has been appointed general manager at Durgapur for the Indian Steelworks Construction Company, as from January 1. Mr. Bell is at present assistant director of research and technical development (tubes) with Stewarts and Lloyds, Limited.

Sidney Flavel & Company, Limited, of Leamington Spa announce that Mr. J. H. FISHWICK, their area manager for South Eastern and Eastern Gas Boards, will in the future be extending his activities to include the area covered by the North Thames Gas Board.

Mr. JOHN WILLIAM ADDY, who until his retirement two years ago was a director of John Addy & Son, Limited, precision engineers and ironfounders, of Clayton West, near Huddersfield, died on November 24 at the age of 82. The company was founded by his great-grandfather in 1820.

British Transport Commission announces the retirement of Mr. C. K. BIRD, C.B.E., general manager of the Eastern Region of British Railways, on grounds of ill-health. He will be succeeded by Mr. H. C. JOHNSON, O.B.E., who is at present assistant general manager (traffic), Eastern Region.

The Castner gold medal of the Society of Chemical Industry, instituted to commemorate the work of Hamilton Young Castner, is one of the Society's major awards. The medal is awarded every two years and for 1958 Dr. R. HOLROYD, deputy chairman of Imperial Chemical Industries, has been appointed Castner medallist.

Mr. EVAN A. NORTON has been appointed chairman of British Rollmakers Corporation in place of Mr. OWEN F. GRAZEBROOK, who has retired from that position. Mr. R. K. CUTHBERTSON has been appointed deputy chairman in place of Mr. JAMES TENNENT, who has retired from that appointment. Both Mr. Grazebrook and Mr. Tennent remain on the board.

Sir STUART GOODWIN, the Sheffield industrialist, has accepted appointment as a governor of King Edward VII Grammar School, his old school. He is one of the school's chief benefactors, and gave £10,000 in 1955 to provide additional recreational and educational facilities. Recently he made a further gift of £1,000 for the addition of shower baths and changing accommodation for the new squash courts.

Mr. KEITH H. ELLSON has been appointed home sales manager of the balance division of Geo. Salter & Company, Limited, of West Bromwich. He will be directly responsible to Mr. J. H. Walter, general sales manager. Mr. Ellson who joined the company in 1948, became, in the latter part of 1951, sales representative covering the Midlands area, and recently he has been senior balance representative for the Midlands.

Mr. FRANK GRUNDY, chief traffic manager of the North Eastern Region, British Railways, has been appointed chief traffic officer, British Railways Central Staff, BTC. Following the retirement of Mr. J. R. PIKE, chief commercial officer, British Railways Central Staff, and the coming retirement of Mr. R. F. HARVEY, chief operating and motive power officer, British Railways Central Staff, these two posts have been merged into the single appointment of chief traffic officer.

Sir WILLIAM WALLACE, chairman and managing director of Brown Bros. & Company, Limited, marine engineers, of Edinburgh, is to retire on December 31. Sir William, who is 76, is well known throughout the shipbuilding industry as the patentee of the Denny-Brown ship stabilizer—a device to reduce the rolling of ships in rough sea. He took out the first provisional patent in 1936 and the device was further improved by his company in partnership with William Denny & Bros., Limited, Dumbarton.

Edgar Allen & Company, Limited announce the retirements of Mr. A. T. WILLIS and Mr. W. A. LONGDEN of their steelfoundry division. Mr. Willis, who joined the firm in 1905, began work as a draughtsman in the foundry drawing office, and later became manager of the foundry ancillary departments. When the machine shops of the foundry and engineering departments were amalgamated, Mr. Willis became co-ordinator. Mr. Longden, who joined the firm in January 1914 as a draughtsman, was appointed chief draughtsman of the foundry in 1916, and later became commercial manager of the steelfoundry division. A third retirement is also notified of Mr. P. G. RYDER formerly technical representative of the engineering department in the London area and home counties.

Obituary

The death is announced of Mr. J. G. PETRIE, the chairman of the board of directors of Bennett's Ironfoundry Company, Limited, Stockport.

The death is announced from Paris of Mr. F. LIBGOTTE, who chaperoned the party of members of the National Society of Master Patternmakers, on their first study tour in France.

The death occurred on November 28 of Mr. JAMES MENZIES MITCHELL, managing director of James Mitchell & Son (Greenock), Limited, tube and pipe bending and fitting specialists.

The death has occurred at the age of 75 of Mr. CHARLES W. STEWART, a partner in J. Alfred Lowes, Limited, engineers' agents and export merchants in shipbuilding and engineering materials, of Sunderland.

Mr. WILLIAM WIGGIN died on November 25, at the age of 82. For many years Mr. Wiggin had been chairman of the family business, J. & J. Wiggin, Limited, ironfounders and stainless steel waremakers, and its two associate companies. Though he had been in poor health for 12 years, Mr. Wiggin took an active interest in the business up to the time of his death.

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Raw Material Markets

Iron and Steel

Current outputs of foundry pig-iron are generally sufficient to satisfy demands, and only in the low-phosphorus irons is there any sign of scarcity. Some producers of this grade are receiving calls for larger tonnages than they can satisfy fully. They are mostly for the engineering and speciality foundries, whose production of castings continues to show an appreciable increase, particularly in the case of the foundries supplying high-duty castings to the motor vehicle trades.

These foundries are taking up all available supplies of the low-phosphorus irons and could take more if outputs permitted, as their inability to obtain full requirements of this grade necessitates the use of larger quantities of the more expensive irons in the hematite grade and to some extent the refined irons. Good tonnages of hematite pig-iron are being taken up and producing furnaces cope easily with these requirements, as well as the refined iron makers, who could undertake larger tonnages if necessary.

The motor vehicle trades maintain their increased usage or castings and, judging by the call for pig-iron from the foundries supplying castings to the machine-tool trades, they are also well provided with work. Power and electrical plant manufacturers, the heavy engineering trades, the collieries, and steelworks provide the engineering and speciality foundries with sufficient work to enable them to obtain good outputs of castings.

The light foundries are the most subdued section of the trade and many of the jobbing and textile foundries also find work difficult to obtain. Demands from the users of castings, including the domestic utensil and building trades, are slow and insufficient to enable them to utilize their full capacity. The high-phosphorus irons show little improvement in demand, although outputs are enough to satisfy a much larger usage. Makers continue to place appreciable tonnages into stock and are able to undertake export business when this is available, although competition from oversea furnaces is becoming more severe.

Dearer money restricts the carrying of stocks, and the orders for pig-iron now being placed are for current consumption with little forward buying. Stocks at the furnaces of most of the normal grades and analyses of pig-iron enable them to despatch supplies promptly.

Sufficient foundry coke is coming to hand, but it is difficult to obtain increased tonnages as many of the coke ovens are fully covered for their outputs. Supplies of scrap are adequate to meet requirements, and ganister, limestone, and firebricks are received to requirements.

The re-rollers continue to obtain fairly good outputs, but there is room for improvement at many plants, as for some products (chiefly small bars and light sections) orders are scarce and this is resulting in short-time working. For the larger sizes of bars and sections business is on a better scale and demands for reinforcing rods and sheets continue at a good level. Generally, however, there is not the same pressure for supplies from the re-rollers as there was some months ago, and forward buying is not so brisk. The re-rollers are well provided with steel semis and, apart from carbons and alloys steels, the steelworks are able to undertake increased business for prompt delivery. There is little demand for defectives and crops.

Non-ferrous Metals

It is early yet to say that the tin situation has been transformed by the actions of the International Tin Council at last week's meeting in London, but it has certainly effected great changes, which should stem the decline in prices. The council decided upon a restriction of exports equivalent to a cut of 28½ per cent. in the annual rate of production in the six countries adhering to the agreement. These countries—the Belgian Congo, Bolivia, Indonesia, Malaya, Nigeria, and Thailand—between them produce 90 per cent. of the world's tin outside the USSR. Their exports between December 15 and March 13 will be restricted to 27,000 tons of tin.

The International Tin Council's main object has been to stop the fall in prices, but it has shown itself anxious also to avoid too sharp a rise. It has therefore empowered the manager of the buffer stock to intervene if necessary. Normally the manager is not permitted to sell tin unless the cash price is £830 or more. He is now empowered to sell when the market is at £781 or higher. He is still not compelled to sell until the market reaches £880 a ton.

The quota restrictions will curtail new supplies by about 25 per cent. and will keep some 10,000 tons of tin off the market between now and March. Prices rose on the announcement of the restrictions, three months' tin benefiting particularly. At one time forward tin was at a discount of £50 compared with cash and it was possible to buy three months' metal and sell it profitably in due course at the buffer stock "floor" price. That margin has now been eliminated. It will take some time for the market to settle down and uncertainty remains as to what will happen after March, but meantime a steadying influence has certainly been introduced.

The other base metals are virtually featureless. Consumption of copper in the United Kingdom and on the Continent is fairly well maintained, but users cannot be described as keen buyers. Lead is a quiet market and has not been greatly stirred by the Board of Trade's decision to slow down the rate of release from the Government stockpile (see below), though this should be a bull point for prices, which, on Monday, reached their lowest level since early 1947.

Trading Loss for F. Perkins

In the first nine months of this year adverse trading conditions have continued to affect F. Perkins, Limited, diesel engine manufacturers, of Peterborough, and a loss has been incurred, according to a circular by the chairman, Mr. F. A. Perkins. "The Suez crisis resulted in a major portion of our oversea and UK markets being substantially reduced through vehicle users of all types reducing their activities," he says. Their most important Eastern market had been virtually closed to them because of internal financial restrictions.

Group net profit contracted from £418,871 to £348,075 in 1956, but the dividend was unchanged at 10 per cent.

Government to Dispose of Lead Stocks

Discussions have been held by the Board of Trade with the interests concerned about the rate of disposal of its remaining stocks of lead of about 20,000 tons. The Board of Trade has invited tenders for the first 7,200 tons for delivery and pricing from January 1, at a rate of 1,200 tons a month. Of this, about 1,900 tons will be offered for sale by open competitive tender and the remainder will be offered to the original suppliers or their agents.

Tender forms are obtainable from the Board of Trade, G7A, Room 316, Lacon House, Theobalds Road, London, W.C.1.

F.&M.

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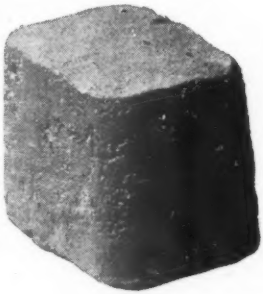

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Many cupola charges require the addition of manganese to combine with the sulphur and form the comparatively innocuous manganese sulphide. Manganese is also needed in the production of cast iron having a medium tensile strength and is essential when a steel scrap is incorporated in the charge.

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Current Prices of Iron, Steel, and Non-ferrous Metals

(*Delivered unless otherwise stated*)

December 10, 1957

PIG-IRON

Foundry Iron.—No. 3 Iron, Class 2:—Middlesbrough, £21 6s. 0d.; Birmingham, £20 18s. 3d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £23 17s. 0d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £24 1s. 3d.

Scotch Iron.—No. 3 foundry, £25 3s. 6d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £25 19s. 0d.; South Zone, £26 1s. 6d.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £27 6s. 6d.; South Zone, £27 9s. 0d.

Hematite.—Si up to 2 per cent., S. & P. over 0.03 to 0.05 per cent.:—N.-E. of England (local iron), £25 6s. 6d.; Scotland (Scotch iron), Zone S. 1, £25 13s. 0d.; Sheffield, £26 15s. 0d.; Birmingham, £27 4s. 0d.; Wales (Welsh iron), £25 6s. 6d.

Basic Pig-iron.—£20 3s. 0d., delivered Staffs, Derbyshire, Notts, Lincs, Rutland, Northants, and Leics.

FERRO-ALLOYS

(*Per ton unless otherwise stated, delivered*)

Ferro-silicon (6-ton lots and over).—45 per cent. Si, £48 10s. 0d. to £50 15s. 0d., scale 17s. 0d. to 17s. 6d. per unit; 75 per cent. Si, £68 10s. 0d. to £76 7s. 6d., scale 17s. 0d. to 17s. 6d. per unit.

Ferro-vanadium.—50/60 per cent., 27s. 6d. per lb. of V.

Ferro-molybdenum.—65/70 per cent., carbon-free, 12s. 6d. per lb. of Mo.

Ferro-titanium.—20/25 per cent., 2-3 per cent. Cu, £250 0s. 0d.; 38/40 per cent., commercially carbon-free, £299 0s. 0d.

Ferro-tungsten.—80/85 per cent., 9s. 0d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 12s. 0d. per lb. of W.

Ferro-chrome (6-ton lots and over).—4/6 per cent. C, £93 0s. 0d. to £96 10s. 0d., basis 60 per cent. Cr, scale 32s. 0d. per unit; over 6 per cent. C, £91 0s. 0d., basis 60 per cent. Cr, scale 31s. 0d. to 32s. 0d. per unit; 2 per cent. C,* 2s. 2d. per lb. Cr.; 1 per cent. C,* 2s. 2½d. per lb. Cr; 0.15 per cent. C.* 2s. 3½d. per lb. Cr; 0.10 per cent. C,* 2s. 3¾d. per lb. Cr; 0.06 per cent. C,* 2s. 4d. per lb. Cr.

Metallic Chromium.—98/99 per cent., 7s. 3d. to 7s. 10½d. per lb.

Metallic Manganese.—90/92 per cent., carbon-free, £290 0s. 0d.; 96/98 per cent., £310 0s. 0d.

Ferro-columbium.—65/75 per cent., Nb + Ta, 22s. 0d. to 22s. 6d. per lb., Nb + Ta.

Ferro-manganese (home).—78 per cent., £87 19s. 3d.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—Basic: Soft, u.t., £33 1s. 6d.; tested, 0.08 to 0.33 per cent. C, £34 1s. 6d.; hard (0.41 to 0.60 per cent. C), £35 3s. 0d.; silico-manganese, £44 2s. 6d.; free-cutting, £37 5s. 6d. Siemens Martin Acid: Up to 0.25 per cent. C, £41 7s. 0d.; silico-manganese, £44 10s. 0d.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.33 per cent. C, £38 16s. 0d.; basic, hard, over 0.41 up to 0.60 per cent. C, £39 18s. 6d.; acid, up to 0.25 per cent. C, £43 10s. 0d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £42 12s. 0d.; boiler plates (N.-E. Coast), £45 2s. 0d.; floor plates (N.-E. Coast), £44 1s. 0d.; angles, N.-E. Coast, £40 6s. 6d.; joists, N.-E. Coast, £40 2s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., and flats, 5 in. wide and under, untested soft basic, 50 tons and over, £40 8s. 0d. (under 10 tons to 4 tons, £41 5s. 6d.; under 4 tons to 2 tons, £41 10s. 6d.); hoop and strip, coils, £40 10s. 0d.; uncoated strip mill coils, hot rolled, under 3mm. to 12g., £45 16s. 0d.; black sheets (hand mill), 24 g., £59 4s. 6d.; galvanized corrugated sheets, 24 g., £68 0s. 0d.

Alloy Steel Bars.—1 in. dia. and up: Nickel, £69 9s. 6d., nickel-chrome, £100 12s. 6d.; nickel-chrome-molybdenum, £112 16s. 6d.

NON-FERROUS METALS

Copper.—Cash, £180 0s. 0d. to £180 5s. 0d.; three months, £184 10s. 0d. to £184 15s. 0d.; settlement, £180 5s. 0d.

Copper Tubes, etc.—Solid-drawn tubes, 1s. 9⅝d. per lb.; rods, 209s. 9d. per cwt. basis; 20 s.w.g., 243s. 0d. per cwt.

Tin.—Cash, £730 0s. 0d. to £731 0s. 0d.; three months, £730 0s. 0d. to £731 0s. 0d.; settlement, £730 10s. 0d.

Lead (Refined Pig).—First half December, £69 5s. 0d. to £69 10s. 0d.; first half March, £71 0s. 0d. to £71 5s. 0d.

Zinc.—First half December, £61 0s. 0d. to £61 5s. 0d.; first half March, £61 10s. 0d. to £61 15s. 0d.

Zinc Sheets, etc.—Sheets, 15g. and thicker, all English destinations £97 10s. 0d.; rolled zinc (boiler plates), all English destinations, £95 5s. 0d.; zinc oxide (Red Seal), d/d buyers' premises, £88 0s. 0d.

Brass Tubes, etc.—Solid-drawn tubes, 1s. 6d. per lb.; sheets to 10 w.g., 161s. 6d. per cwt. wire, 2s. 3½d.; rolled metal, 161s. 6d. per cwt.

Brass (Brazing).—BS1400, B3 (65/35), £136; B6 (85/15), — ; BS249, —.

Brass (High Tensile).—BS1400, HTB1 (30 tons), £180; HTB2 (38 tons), — ; HTB3 (48 tons), £207.

Gunmetal.—BS1400, LG2 (85/5/5/5), £167; LG3 (86/7/5/2), £178; G1 (88/10/2/½), £235; (88/10/2/1), — .

Phosphor Bronze.—BS1400, PB1 (AID released), — per ton.

Phosphor Bronze Strip, etc.—Strip, 236s. 0d. per cwt.; sheets to 10 w.g., — per cwt.; wire, 3s. 6¾d. per lb.; rods, 2s. 10½d.; tubes, 2s. 10½d.; chill cast bars: solids 2s. 10d., cored 2s. 11d. (Charles Clifford, Limited.)

Nickel Silver, etc.—Rolled metal, 3 in. to 9 in. wide × 0.056, 3s. 5½d. per lb.; round wire, 10g. in coils (10 per cent.), 3s. 10d.; special quality turning rod, 10 per cent., ½ in. dia., in straight lengths, 3s. 9d. All prices are net.

Other Metals.—Magnesium, ingots, 2s. 5½d. per lb. Antimony, English, 99 per cent., £190 0s. 0d. Quicksilver, ex-warehouse, £69 0s. 0d. Nickel, £600 0s. 0d. Aluminium ingots, £197 0s. 0d.; aluminium bronze (BS1400), AB1, £215; AB2, £225.

* Average 68-70 per cent.